NASA

National Aeronautics and
Space Administration

Budget Estimates

Fiscal Year 1993

Volume I

Agency Summary

Research and Development

Space Flight, Control and Data Communications

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1993 ESTIMATES

VOLUME 1

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AGENCY
SUMMARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1993 BUDGET ESTIMATES

AI STATEMENT

The National Aeronautics and Space Administration conducts space and aeronautical research, development and flight activities for peaceful purposes designed to maintain United States preeminence in aeronautics and space. The President, in the National Space Policy, has charged NASA to conduct a balanced program of manned and unmanned exploration and to begin the systematic development of technologies necessary to enable and support a range of future manned missions. These activities will support the long-range goal of expanding human presence and activity beyond Earth orbit into the solar system. NASA remains committed to maintaining the United States as the preeminent spacefaring nation.

The NASA FY 1993 budget request of $14.993 billion maintains strong support for the President's policy and is responsive to the fiscal realities of restrained growth in spending. This budget concentrates on:

- Continuing an effective Space Science and Applications program to expand our knowledge of the solar system and the universe as well as the Earth, in an effort to understand the nature of global environmental problems;

- Providing safe and effective assured access to space using both the Space Shuttle and Expendable Launch Vehicles and improving the efficiency of the Space Shuttle operations;

- Moving forward in the development of the Space Station Freedom, as it moves closer to first element launch in 1996, the attainment of a man-tended capability in 1997, and a permanently manned capability in late 2000;

- Providing the technology, expertise and facilities necessary for superiority in civil and military aviation;

- Supporting a vigorous space technology program essential to the future of the U.S. space program;

- Continuing the participation of NASA with DoD in the joint New Launch System (NLS) and National Aerospace Plane (NASP) programs, leading to first launch of the NLS in 2002 and completion of the NASP vehicle technology and design (Phase 11) in FY 1994;

- Supporting exploration activities that focus on the Moon and Mars;

- Providing opportunities for commercialization of space and for international cooperation in space;

- Supporting the Presidential initiatives to strengthen the worldwide position of the United States in science education, global environmental research, high performance computing, biotechnology research and development, and advanced materials and processing;

The budget plan proposed for FY 1993 assumes implementation of the initial FY 1992 Operating Plan which is currently under review. In response to a recommendation of the Advisory Committee on the Future of the U.S. Space Program (December 1990), a review of the roles and mission of each of the NASA centers and Headquarters was undertaken during 1991. That review has resulted in a decision to sharpen the focus at the NASA field installations by creating "Centers of Excellence". This budget begins the implementation of the realignment of activities resulting from this decision which will be phased in over the next year.

In total, the program elements outlined in this budget will provide a strengthened base for assuring and continuing the United States' role as leader in space and aeronautical research and development. Specific major areas of emphasis are:

Space Science and Applications

The Space Science and Applications program is designed to expand our understanding of scientific phenomena ranging from the intricacies of the universe to the subtleties of the planet Earth. The FY 1993 budget provides for a carefully coordinated and logically phased set of research and development activities to:

- Advance our scientific knowledge of Earth and the global processes which shape our environment;

- Explore the solar system using automated spacecraft in conjunction with ground-based observations and research;

- Expand our comprehension of the universe beyond the solar system using the full range of capabilities from Explorer spacecraft to the "Great Observatories";

- Increase our knowledge in the life sciences on key issues ranging from human performance and habitation in space to the basic life processes and the potential of life elsewhere in the universe;

- Understand and develop the potential benefits of the microgravity environment in materials sciences and other applications.

The Space Science and Applications program continues to experience an ever increasing level of activity. A vigorous launch schedule is planned for 1992-1993. This includes: the Extreme Ultraviolet Explorer (EWE); the Mars Observer mission; the Advanced Communications Technology Satellite (ACTS); the first flight of the Tethered Satellite System (TSS); the Global Geospace Science Wind mission, an element of the U.S. contribution to the International Solar Terrestrial Physics program (ISTP); Lageos II, which will aid in the study of crustal dynamics; and several Spacelab missions to study microgravity materials processing, life sciences, space physics and the Earth's environment. Development continues on the Advanced X-Ray Astrophysics Facility (AXAF) and the Cassini mission to study Saturn. The budget proposes termination of the Comet Rendezvous/Asteroid Flyby (CRAF) mission and the Shuttle Test of Relativity Experiment (STORE) mission. Funding is included to initiate research on "smallsat" technology for planetary missions and to fund the NASA portion of the cooperative NASA/DoD Landsat follow-on program. A management plan is currently being formulated. Funding is also included for the operations and data analysis activities of the missions scheduled for launch as well as previously launched missions, and for preparation for servicing of the Hubble Space Telescope with advanced instrumentation and correction of the spherical aberration in the primary mirror. Preparation for utilization of the Space Station Freedom continues, emphasizing both microgravity and life science research, while a vigorous, multidisciplinary program of basic and applied research will continue.

NASA provided a major contribution to the multiagency U.S. Global Change Research Program with the launch of the Upper Atmosphere Research Satellite (UARS) in 1991. UARS will provide a global database necessary for understanding the chemistry, dynamics and energetics of the upper atmosphere and the effects of solar radiation on these characteristics. The Earth Observing System (EOS) and the Earth Probes program are the major NASA contributions to the U.S. Global Change Research Program and remain high NASA priorities. The EOS program has recently undergone a major restructuring activity to respond to Congressional direction to reduce program costs through 2000, as well as the engineering assessment conducted by the EOS Engineering Review panel and other external recommendations. Changes in the EOS platform configuration, instrument complement and launch dates have resulted from this review which will increase the flexibility of EOS and reduce risk. Funding for the EOS Data Information System (EOSDIS) is continued. An assessment by the National Academy of Sciences of EOSDIS, to be conducted in 1992, will help ensure that it is compatible and complementary to the restructured EOS program. Funding for the Earth Probes, which will address specific, highly-focused Earth science investigations requiring unique orbits or special sensor environments will continue. This program includes a Total Ozone Mapping Spectrometer (TOMS) free flyer scheduled for launch in 1993, a TOMS instrument which will be launched aboard the Japanese ADEOS mission, the Scatterometer scheduled for launch in 1995 and the Tropical Rainfall Mapping Mission (TRMM) scheduled for launch in 1997. In addition, a TOMS instrument was launched aboard a Soviet spacecraft in 1991.

Space Transportation

Space Transportation is comprised of three major areas: the Space Shuttle; Expendable Launch Vehicles; and the New Launch System. The primary focus of the Shuttle program is to conduct the planned flights in a safe and reliable manner and use the Shuttle's capability in the most efficient and prudent fashion. The budget provides for conducting 8 missions per year through FY 1996, and 9 missions annually thereafter. A total of 8 flights were accomplished in FY 1991, including the launch of the Ulysses, Compton Observatory, UARS and TDRS-5 spacecraft as well as highly successful Spacelab missions in life sciences (SLS-1) and astronomy (ASTRO-1), and two DoD missions. The requested funding for Shuttle operations incorporates efficiency savings of about 3 percent per year from previously budgeted levels, starting in FY 1992. Although production of additional orbiters is not planned, the Shuttle structural spares program is continued to maintain key manufacturing skills at the contractor facility needed to satisfy the operational requirements of the existing orbiter fleet and to help preserve the near-term option to build an additional orbiter if required. This is consistent with the National Space Launch strategy. Funding for the development of the Alternate Fuel Pump has been suspended so that efforts can be focused on the more critical liquid oxygen pump. Funding for the Advanced Solid Rocket Motor has been deleted after FY 1992 due to the significant funding required.

In order to satisfy NASA payload requirements, Expendable Launch Vehicle (ELV) services are funded in addition to the Shuttle. ELV launch services are obtained from the private sector except for payloads exceeding 30,000 lbs to low Earth orbit, in which case these services are acquired through the DoD. Currently, only a Titan IV/Centaur vehicle in support of the Cassini launch in October 1997 is being procured through the DoD. Other ELVs being funded include Pegasus vehicles for small payloads; Delta IIs for medium size payloads like Wind, Polar, Geotail, and Radarsat; and Titan 111s and Atlas-IIAS class vehicles for payloads like the Mars Observer and the SOHO. New missions being funded in FY 1993 include the US/Argentina SAC-B/HETE, the X-Ray Timing Explorer, and the Lunar Resources Mapper which is a precursor mission in support of the Space Exploration program.

The New Launch System (NLS) is a joint NASA/DOD development program which will develop a launch vehicle system for a range of'cargo capabilities addressing the needs of both agencies. The NLS will provide both near-term capability that is evolutionary and a longer-term capability that incorporates new technology. The NLS was recommended by the Committee on the Future of Space to reduce operating costs, improve reliability, and mission performance. Current plans call for the first NLS flight to take place in the year 2002.

Space Station Freedom

The Space Station Freedom remains a critical element in this nation's exploitation of space in the future. It will support scientific and technological investigations, provide experience in long-term human operations in space critical to future manned space exploration, and further the commercial utilization of space. It is an avenue of cooperation with our allies, demonstrating the peaceful uses of space for the benefit of all.

Progress continues to be made in implementing the restructured program, with the first element launch scheduled for 2nd quarter FY 1996, man-tended capability scheduled for 3rd quarter 1997 and permanently manned capability for late FY 2000. In FY 1993, the Space Station Freedom will conduct its Critical Design Review, which, as a result, will finalize the detailed design of the man-tended Space Station systems and elements. Funding is included for definition studies for the design, schedule and cost of an assured crew return capability. FY 1993 will be the first year that funding will be provided for operations, including initial lay-in of long-lead spares and Space Station utilization management activity, previously planned by the Office of Space Science and Applications.

Aeronautics Research and Technoloev

Aviation in general, and the aeronautics industry in particular, play a major role in supporting the economic strength, transportation infrastructure and national defense capabilities required for the long-term well being of the United States. The goal of the Aeronautics program is to conduct aeronautical research and develop technology to strengthen the U.S. leadership in civil and military aviation. This is accomplished by maintaining a broad-based research and technology program utilizing advanced facilities, laboratories, computers and technical staff, with extensive involvement of the U.S. university and industrial sectors.

This budget request maintains a strong commitment to develop a broad technology base in support of the aviation industry, enhance safety and capacity of the national airspace system, and assure U.S. superiority for national defense. Funding is included to continue addressing critical environmental compatibility issues and to establish a foundation for subsequent decisions on future high-speed civil transport technology and development programs. In FY 1993, the high-speed research program will submit an interim assessment of the effect on the atmosphere of stratospheric aircraft to the National Academy of Sciences for a critical review. The direction of further research will be determined by the outcome of aerodynamic analyses scheduled for FY 1993. Increased funding is included for the advanced subsonic technology program, which will focus on selected high payoff technologies in aging aircraft and fly-by-light/power-by-wire flight control systems. NASA's technology program will be conducted in close cooperation with the FAA as a national program in aging aircraft structural integrity. NASA will also continue as a full and active participant in the multiagency

High Performance Computing and Communications (HPCC) program. NASA's activities are focused on enabling broad advances in aerospace vehicle design, space and Earth systems science. This approach leverages current NASA leadership, while broadly strengthening its capability for sustained high performance computing research.

Space Research and Technology

This program develops the technology base on which our current and future capabilities in space depend. The FY 1993 research and technology program is responsive to the strong and continuing consensus that investments in advanced research and technology are essential to our future success in space. A new strategic planning process has been implemented to more effectively address space technology needs foreseen by potential users within NASA as well as other government agencies and industry. This budget request is based on the results of the first cycle of this planning process. Beginning in FY 1993, the program has been restructured to be more consistent with the strategic and programmatic thrusts the program supports. It will consist of *two* complementary parts; the Research and Technology (R&T) Base, and the focused Civil Space Technology Initiative (CSTI) program. The R&T Base will continue to serve as the seedbed for new technologies and capability enhancement. Fundamental research will be conducted in critical disciplines, and high-leverage technology advances and concepts will be brought to the level of demonstrating proof of principle. Funding for the In-Space Technology Experiments (In-STEP) program will be included in the R&T Base and will continue to support the development of small flight experiments to conduct research to demonstrate critical technologies that cannot be validated on the ground.

The CSTI has been restructured to establish budget elements that are identical to the five strategic thrusts they support - space science technology, space transportation technology, planetary surface technology, space platforms technology and operations technology. The CSTI will continue to provide specifically for the development of selected technologies at larger scale or higher levels of maturity and, as required, in the relevant environment of space. This will facilitate a more effective transfer to the technology user programs. Also in FY 1993, Advanced Communications Research, previously funded in the OSSA program, will be transferred to Space Research and Technology. These activities address the development of high-risk technology and are consistent with the Space R&T advanced development program.

Transatmospheric Research and Technology

The NASA efforts in the joint National Aero-Space Plane (NASP) program with DoD are aimed at accelerating the development of critical technologies intended to enable a potential new class of vehicles capable of flight to orbit or hypersonic cruise. Funding is included to continue NASA's participation in the program. The decision on building the X-30 flight research vehicle has been deferred until the last quarter of FY 1993.

Space Exploration

Funding is included to initiate exploration activities that focus on the Moon and Mars. Two small lunar missions are proposed to provide the resource mapping, geographic, gravity and topographic information required to pursue further mission planning. These missions will emphasize available technology, involvement of the university community and in-house workforce, and use of existing, flight-ready subsystems. Funds are also included for mission studies to continue the architecture studies and planning activities supporting the goal of human exploration of the solar system. More ambitious missions, particularly manned exploration of the Moon and Mars, will require significant improvements and breakthroughs in space transportation and other areas. Long-term technology development efforts in these areas will be implemented as future needs are identified.

Commercial Activities

The FY 1993 budget request continues NASA's commitment to encouraging a healthy and expansive commercial space industry. Funding is included to support the Centers for the Commercial Development of Space (CCDS) and to support the flight tests required to support CCDS activities. Continued development of the Commercial Middeck Augmentation Module (CMAM), the Commercial Experiment Transporter (COMET) and the commercial sounding rocket program conducted by several CCDS's are major program and budget activities planned for FY 1993.

NASA also seeks to involve the commercial sector in developing the infrastructure for research and working in space. NASA continues to procure launch services from the private sector for a number of scientific satellite missions. Commercially-developed upper stages are being used where appropriate for planned missions. The Extended Duration pallet, to extend the Shuttle on-orbit stay time to 16 days, is being procured on a commercial basis. Through the Technology Utilization program, we enhance and accelerate the application and use of aeronautics and space technology by the public, private and academic sectors.

Space and Ground Network, Communications and Data Systems

The FY 1993 budget provides the vital tracking, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. The Second TDRSS Ground Terminal (STGT) will be operational in FY 1993 and work on the upgrade of the current White Sands Ground Terminal will continue. Launch of the replacement TDRS (TDRS-7) is planned for 1995 on the Space Shuttle. The TDRS II development program will begin in early FY 1993 to ensure uninterrupted Space Network operational services to flight missions.

Academic Programs

Science and mathematics achievement is an integral element of the President's Education Initiative and NASA's Academic programs strongly support making U.S. students first in the world in science and mathematics achievement by the year 2000. NASA has been an active member of the Committee on Education and Human Resources, which has been charged with formulating the strategy for science, mathematics, engineerlng and technical education. The agency's programs at the pre-college, college and graduate levels are designed to capture and channel student interest in science, engineering, mathematics and technology as well as enhance teacher knowledge and skills related to these subjects. Funding for these programs will continue to expand NASA's graduate and undergraduate student fellowships, faculty fellowships, research and training grants at the historically black colleges and universities as well as other minority universities, and the Space Grant College and Fellowship program.

Institutional Capability

The NASA institutional capability is the fundamental underpinning for successful accomplishment of the nation's aeronautics and space program. This capability is comprised of the people who plan, conduct and oversee the research, development and test activities of NASA, as well as the valuable and unique NASA facilities. As is reflected in the FY 1992 Initial Operating Plan, management and funding of the activities previously budgeted under Operation of Installations in the Research and Program Management appropriation have been transferred to the Program Offices as Research Operations Support. These funds will be augmented by directly charging programs for requirements previously provided for in the R&PM appropriation as an interim step in the development of a system to budget and manage these activities. The Construction of Facilities program continues the multi-year effort to restore, modernize and maintain the aeronautical research and development facilities and the facilities necessary to support processing of the Space Station hardware and payloads.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1993 BUDGET SUMMARY
(Millions of Dollars)

	Budget Plan		
	1991	1992	1993
RESEARCH AND DEVELOPMENT	6023.6	6850.8	7731.4
Space station	1900.0	2028.9	2250.0
Space transportation capability development	602.5	731.5	863.7
Space science and applications	2431.1	2715.a	2985.0
Technology utilization	24.4	32.5	31.7
Commercial use of space	63.6	116.1	139.9
Aeronautical research and technology	512.0	774.6	890.2
Transatmospheric research and technology	95.0	20.0	80.0
Space research and technology	286.9	309.0	332.0
Space exploration	(3.5)	(5.0)	31.8
Safety, reliability and quality assurance	33.0	33.6	32.5
Academic programs	55.1	66.8	71.4
Tracking and data advanced systems	20.0	22.0	23.2
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	5124.4	5384.a	5266.5
Shuttle production and operational capability	1314.0	1327.8	1012.a
Shuttle operations	2752.4	2943.4	3115.2
Expendable launch vehicles	229.2	195.3	217.5
Space and ground networks, communications and data systems	828.a	918.3	921.0
CONSTRUCTION OF FACILITIES	497.9	525.0	319.2
RESEARCH AND PROGRAM MANAGEMENT	2211.6	1577.6	1660.0
INSPECTOR GENERAL	10.5		15.9
TOTAL BUDGET SUMMARY	13868.0	14352.a	14993.0
OUTLAYS	13876.6	13817.9	14086.9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1993 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS

(Millions of Dollars)

	TOTAL	R & D	SFC&DC	CofF	R&PM	IG
Fiscal Year 1991						
Appropriation P.L. 101-507	15,078,032	6,023,600	6,334,132	497,900	2,211,900	10,500
Portion applied to debt reduction	-1,209,732		-1,209,732			
Reduction pursuant to P.L. 100-119	-179	-78	-66	-6	-29	
Lapse of FY 1991 Unobligated Funds	-274				-	-35
Total Budget Plan	13,867,847	6,023,522	5,124,334	497,894	2,211,632	10,465
Fiscal Year 1992						
Appropriation P.L. 102-139	14,352,775	6,413,800	5,157,075	525,000	2,242,300	14,600
Appropriation Transfer		436.956	227.700		-664.656	
Total Budget Plan	14,352,775	6,850,756	5,384,775	525,000	1,577,644	14,600
Fiscal Year 1993						
Appropriation Request/Budget Plan	14.993.022	7.731.400	5.266.500	319.200	1.660.027	15.900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1993 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION

(Thousands of Dollars)

	Total			Space Flight Control and Data Communications			Research and Development			Construction of Facilities			Research and Program Management		
	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993
Johnson Space Center	2,739,786	2,825,671	3,104,026	1,185,700	1,197,000	1,324,700	1,161,735	1,353,754	1,507,435	53,891	30,910	16,450	338,460	244,007	255,441
Kennedy Space Center	1,499,580	1,551,574	1,641,630	923,700	1,031,900	1,064,000	210,292	283,619	364,017	66,633	80,215	49,200	298,955	155,840	164,413
Marshall Space Flight Center .	3,253,160	3,251,259	3,134,615	1,937,275	1,941,000	1,692,700	966,059	1,047,166	1,178,578	63,671	35,246	26,200	286,155	227,847	237,137
Stennis Space Center..........	95,271	99,593	93,216	24,600	41,000	30,600	16,540	24,393	32,329	25,595	19,355	13,965	28,536	14,845	16,322
Goddard Space Flight Center ..	2,167,144	2,119,382	2,245,019	674,100	701,400	686,600	1,153,016	1,127,342	1,252,664	36,942	39,965	41,175	303,086	250,675	264,580
Jet Propulsion Laboratory	834,253	943,178	937,951	150,399	177,800	186,100	649,292	750,843	743,531	34,562	14,535	8,320	0	0	0
Ames Research Center	607,256	663,287	735,256	18,600	18,900	21,900	349,951	443,042	500,248	27,550	39,280	40,880	211,155	162,065	172,228
Langley Research Center	528,257	543,160	578,870	330	0	0	279,441	344,565	380,135	33,955	26,480	19,070	214,531	172,115	179,665
Lewis Research Center	950,575	909,174	1,045,841	122,760	61,200	62,800	554,493	656,271	771,383	43,262	18,640	28,520	230,060	173,063	183,138
Headquarters	1,078,909	1,213,768	1,389,708	86,790	213,775	197,100	682,703	819,761	1,001,080	8,642	2,245	4,425	300,774	177,987	187,103
Undistributed Construction of Facilities:															
Various Locations	75,191	104,129	44,295	0	0	0	0	0	0	75,191	104,129	44,295	0	0	0
Facility Planning and Design	28,000	34,000	26,700	0	0	0	0	0	0	28,000	34,000	26,700	0	0	0
Total Budget Plan	13,857,382	14,338,175	14,977,127	5,124,334	5,384,775	5,266,500	6,023,522	6,850,756	7,731,400	497,894	525,000	319,200	2,211,632	1,577,644	1,660,027
Inspector General.............	10,465	14,600	15,900	---	---	---	---	---	---	---	---	---	---	---	---
Total Agency..................	13,867,847	14,352,775	14,993,027												

DISTRIBUTION OF FULL TIME EQUIVALENT WORKYEARS BY INSTALLATION

	1991 ACTUAL	1992 BUDGET ESTIMATE	1992 CURRENT ESTIMATE	1993 BUDGET ESTIMATE
JOHNSON SPACE CENTER	3,624	3,617	3,631	3,631
KENNEDY SPACE CENTER	2,503	2,509	2,517	2,510
MARSHALL SPACE FLIGHT CENTER	3,640	3,650	3,650	3,650
STENNIS SPACE CENTER	205	216	216	216
GODDARD SPACE FLIGHT CENTER	3,883	3,975	3,983	3,985
AMES RESEARCH CENTER	2,219	2,227	2,225	2,225
LANGLEY RESEARCH CENTER	2,931	2,925	2,925	2,925
LEWIS RESEARCH CENTER	2,799	2,791	2,790	2,787
HEADQUARTERS	1,892	2,030	2,006	2.006
SUBTOTAL, FULL-TIME PERMAMENT WORKYEARS	23,696	23,940	23,943	23,935
OTHER THAN FULL-TIME PERMAMENT WORKYEARS	300	291	288	296
SUBTOTAL, CEILING CONTROLLED FTE	23,996	24,231	24,231	24,231
CORE		595	300	500
GRAND TOTAL, CEILING CONTROLLED FTE	23,996	24,826	24,531	24,731

MULTI-YEAR
BUDGET

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1993 ESTIMATES

The FY 1993 multi-ye r budget estimate is submitted in accordance with the NASA FY 1989 Authorization Law (P.L. 100-685). The attached table contains the budget estimates for FY 1993, along with the Administration's projections for 1994 and 1995. Consistent with Administration policy the funding levels for FY 1994 and FY 1995 are held at the FY 1993 level. It is expected that NASA space and aeronautics activities will compete for available resources in future budgets against the other discretionary programs and that proposed changes in future funding levels will not be determined until the time those budget decisions are made.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1993 MULTI-YEAR BUDGET ESTIMATES
IN MILLIONS OF REAL YEAR DOLLARS

FY 1993 PRESIDENT'S BUDGET

	1991 PAST YEAR	1992 CURRENT YEAR	1993 BUDGET YEAR	1994 ESTIMATE	1995 ESTIMATE
RESEARCH AND DEVELOPMENT	6023.6	6850.8	7731.4	7731.4	7731.4
SPACE STATION	1900.0	2028.9	2250.0	2250.0	2250.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	602.5	731.5	863.7	863.7	863.7
PHYSICS & ASTRONOMY	969.2	1047.3	1113.5	1113.5	1113.5
LIFE SCIENCES	137.4	145.8	177.2	177.2	177.2
PLANETARY EXPLORATION	473.7	535.6	487.2	487.2	487.2
SPACE APPLICATIONS	850.8	987.1	1207.1	1207.1	1207.1
SPACE SCIENCE AND APPLICATIONS	2431.1	2715.8	2985.0	2985.0	2985.0
TECHNOLOGY UTILIZATION	24.4	32.5	31.7	31.7	31.7
COMMERCIAL USE OF SPACE	63.6	116.1	139.9	139.9	139.9
COMMERCIAL PROGRAMS	88.0	148.6	171.6	171.6	171.6
AERONAUTICAL RESEARCH & TECHNOLOGY	512.0	774.6	890.2	890.2	890.2
SPACE RESEARCH & TECHNOLOGY	286.9	309.0	332.0	332.0	332.0
TRANSATMOSPHERIC RESEARCH & TECHNOLOGY	95.0	20.0	80.0	80.0	80.0
SPACE EXPLORATION	(3.5)	(5.0)	31.8	31.8	31.8
SAFETY, RELIABILITY & QUALITY ASSURANCE	33.0	33.6	32.5	32.5	32.5
ACADEMIC PROGRAMS	55.1	66.8	71.4	71.4	71.4
TRACKING AND DATA ADVANCED SYSTEMS	20.0	22.0	23.2	23.2	23.2
SPACE FLIGHT. CONTROL & DATA COMMUNICATIONS	5124.4	5384.8	5266.5	5266.5	5266.5
SHUTTLE PRODUCTION & OPERATIONAL CAP	1314.0	1327.8	1012.8	1012.8	1012.8 / 3115.2
SHUTTLE OPERATIONS	2752.4	2943.4	3115.2	3115.2	
EXPENDABLE LAUNCH VEHICLES	229.2	195.3	217.5	217.5	217.5
SPACE & GROUND NETWORKS, COMMUNICATIONS & DATA SYSTEMS	828.8	918.3	921.0	921.0	921.0
CONSTRUCTION OF FACILITIES	497.9	525.0	319.2	319.2	319.2
RESEARCH AND PROGRAM MANAGEMENT	2211.6	1577.6	1660.0	1660.0	1660.0
INSPECTOR GENERAL	10.5	14.6	15.9	15.9	15.9
TOTAL NASA	13868.0	14352.8	14993.0	14993.0	14993.0

RESEARCH AND
DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the technology for practical applications of space technology; to develop and improve manned and unmanned space vehicles; and to assure continued development of the long-term aeronautics and space research and technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE STATION: A program to develop a United States space station to continue the Nation's leadership in space and to provide for enhancement of science and applications programs and to further the commercial utilization of space while stimulating advanced technologies.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT: A program to provide for the development and use of capabilities primarily related to the Space Shuttle. The principal areas of activity in Space Transportation Capability Development are efforts associated with the jointly developed NASA/DOD New Launch System; development and operations of the Spacelab system for NASA Shuttle payloads; engineering and technical base support at the manned NASA centers; payload operations and support equipment; development and flight certification of the joint United States/Italian Tethered Satellite System; and advanced programs study and evaluation efforts.

SPACE SCIENCE AND APPLICATIONS: A program using space systems, supported by ground-based and airborne observations: (1) to conduct a broad spectrum of scientific investigations to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, the stars of our galaxy and the universe; and (2) to identify and develop the technology for the useful applications of space techniques in the areas of advanced communications satellite systems technology; materials processing research and experimentation; and remote sensing to acquire information which will assist in the solution of Earth resources and environmental problems.

TECHNOLOGY UTILIZATION: The program includes activities to accelerate the dissemination of advances achieved in NASA's research, technology, and development program to both the public and the private sectors.

COMMERCIAL USE OF SPACE: A program to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development.

AERONAUTICS AND SPACE TECHNOLOGY: A program to conduct the fundamental long-term research and to develop the discipline and systems technology required to maintain United States leadership in aeronautics and space.

SPACE EXPLORATION: A program that supports exploration activities that focus on the Moon and Mars

SAFETY, RELIABI QUALITY ASSURANCE: A program to [illegible]ce the safety and technical execution of NASA programs.

ACADEMIC PROGRAMS: This program includes activities to support agencywide university, minority university, and elementary and secondary school programs.

TRACKING AND DATA ADVANCED SYSTEM: This program includes activities to perform studies and provide for the development of systems and techniques leading to improve tracking and data program capabilities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT
FISCAL YEAR 1993 ESTIMATES

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Millions of Dollars)		
SPACE STATION	1900.0	2028.9	2028.9	2250.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	602.5	879.8	731.5	863.7
SPACE SCIENCE AND APPLICATIONS	2431.1	2934.6	2715.8	2985.0
Physics and astronomy	969.2	1140.6	1047.3	1113.5
Life sciences	137.4	183.9	145.8	177.2
Planetary exploration	473.7	627.3	535.6	487.2
Earth sciences	662.3	775.6	738.5	868.5
Materials processing	102.3	125.8	118.8	195.3
Communications	50.5	39.4	12.5	4.6
Information systems	35.7	42.0	117.3	138.7
COMMERCIAL PROGRAMS	88.0	150.0	148.6	171.6
Technology utilization	24.4	32.0	32.5	31.7
Commercial use of space	63.6	118.0	116.1	139.9
AERONAUTICS AND SPACE TECHNOLOGY	893.9	1085.0	1103.6	1302.2
Aeronautical research and technology ...	512.0	591.2	774.6	890.2
Transatmospheric research and technology	95.0	72.0	20.0	80.0
Space research and technology	286.9	421.8	309.0	332.0
SPACE EXPLORATION	(3.5)	(15.0)	(5.0)	31.8
SAFETY, RELIABILITY AND QUALITY ASSURANCE	33.0	33.6	33.6	32.5
ACADEMIC PROGRAMS	55.1	64.6	66.8	71.4
TRACKING AND DATA ADVANCED SYSTEMS	20.0	22.0	22.0	23.2
TOTAL	6023.6	7198.5	6850.8	7731.4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; purchase, [hire] *lease, charter,* maintenance. and operation of [other than] ***mission and*** administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration; **[$6,413,800,000]** ***not to exceed $35,000 for official reception and representation expenses; and purchase (not to exceed thirty-three for replacement only) and hire of passenger motor vehicles; $7,731,400,000***, to remain available until September 30, [1993] ***1994.*** ***(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act. 1992; additional authorizing legislation to be proposed.)***

[The last proviso under this heading in the Department of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1990 (Public Law 101-144), is hereby deleted.] ***(Dire Emergency Supplemental Appropriations Act. 1992.)***

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

S Y

(In thousands of dollars)

	FY 1991	FY 1992 (Budnet Plan)	FY 1993 (Budnet Plan)
Space station	1,147	1,704	1,638
Space transportation capability development	67,280	117,864	115,513
Space science and applications	338,557	347,965	324,169
Commercial programs	7,471	9,891	10,726
Aeronautical research and technology	51,314	45,320	43,242
Transatmospheric research and technology	5,408	28,079	30,000
Space research and technology	22,598	28,055	30,570
Academic programs	355	325	355
Safety, reliability and quality assurance	310	363	500
Energy technology	17,672	15,668	15,640
Total	512,112	595,234	572,353

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1993 ESTIMATES
DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Station	1991	1,900,000	853,800	64,200	381,500	---	108,000	7,600	1,700	3,600	294,600	185,000
	1992	2,028,900	941,000	106,200	456,800	---	---	3,900	600	2,900	307,400	210,100
	1993	2,250,000	1,012,700	156,200	500,800	---	---	2,900	100	2,000	352,400	222,900
Space Trans Cap Dev	1991	602,467	196,300	121,500	247,100	9,300	12,400	700	---	2,000	1,900	11,267
	1992	731,456	262,400	148,500	242,100	15,800	11,400	300	---	1,100	900	48,956
	1993	863,700	302,400	173,900	298,000	22,900	9,900	400	---	700	500	55,000
Space Sci and Apps	1991	2,431,067	78,531	18,559	276,286	409	1,008,449	580,622	119,812	30,670	69,516	248,213
	1992	2,715,800	83,481	20,295	314,965	778	1,080,385	675,411	141,415	36,895	49,983	312,192
	1993	2,985,000	102,927	24,001	345,262	909	1,202,394	663,825	159,943	44,874	69,736	371,129
Physics and Astronomy	1991	969,167	16,919	13,312	226,675	---	619,041	27,462	13,290	---	---	52,468
	1992	1,047,300	14,728	14,763	258,804	---	636,529	37,629	13,848	---	---	70,999
	1993	1,113,500	16,927	17,659	261,577	---	668,680	51,558	24,413	---	---	72,686
Life Sciences	1991	137,400	47,814	5,172	---	40	570	1,525	56,503	901	---	24,875
	1992	145,800	53,566	5,532	---	48	619	1,285	58,423	952	---	25,375
	1993	177,200	68,457	6,342	---	56	723	1,501	65,133	1,112	---	33,876
Planetary Exploration	1991	473,700	12,447	---	429	---	21,596	354,626	15,540	620	---	68,442
	1992	535,600	12,900	---	800	---	11,900	400,900	17,100	650	---	91,350
	1993	487,200	13,700	---	1,000	---	23,600	320,700	10,400	700	---	117,100
Earth Science & Apps	1991	662,300	---	75	11,169	369	344,980	163,679	28,032	26,816	---	87,180
	1992	738,500	---	---	11,800	730	349,288	212,360	44,420	31,780	---	88,122
	1993	868,500	---	---	13,797	853	410,909	250,805	51,939	37,159	---	103,038
Materials Proc in Space	1991	102,300	1,326	---	37,413	---	80	22,890	---	2,333	31,057	7,201
	1992	118,800	2,287	---	43,561	---	110	19,779	---	3,513	39,483	10,067
	1993	195,300	3,843	---	68,888	---	185	33,232	---	5,903	66,336	16,913
Communications	1991	50,500	25	---	---	---	2,822	6,326	---	---	38,459	2,868
	1992	12,500	---	---	---	---	650	300	---	---	10,500	1,050
	1993	4,600	---	---	---	---	600	200	---	---	3,400	400
Information Systems	1991	35,700	---	---	600	---	19,360	4,114	6,447	---	---	5,179
	1992	117,300	---	---	---	---	81,289	3,158	7,624	---	---	25,229
	1993	138,700	---	---	---	---	97,697	5,829	8,058	---	---	27,116

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1993 ESTIMATES
DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Commercial Programs	1991	88,000	14,840	1,082	1,337	5,196	2,100	466	1,005	1,083	1,790	59,101
	1992	148,600	44,155	1,413	2,130	5,500	2,752	2,566	1,310	1,260	5,566	81,948
	1993	171,600	55,530	1,975	2,727	5,670	2,910	2,341	1,112	1,320	7,106	90,909
Technology Utilization	1991	24,400	4,290	482	387	546	900	466	555	733	520	15,521
	1992	32,500	3,955	413	930	750	1,252	625	710	960	775	22,130
	1993	31,700	2,380	425	877	570	1,460	600	412	620	716	23,640
Commercial Use Of Space	1991	63,600	10,550	600	950	4,650	1,200	---	450	350	1,270	43,580
	1992	116,100	40,200	1,000	1,200	4,750	1,500	1,941	600	300	4,791	59,818
	1993	139,900	53,150	1,550	1,850	5,100	1,450	1,741	700	700	6,390	67,269
Aero & Space Technology	1991	893,888	14,061	2,150	55,914	440	11,874	38,127	225,399	238,858	182,575	124,490
	1992	1,103,600	17,900	4,200	25,300	500	20,900	46,700	297,900	296,700	286,200	107,300
	1993	1,302,200	14,100	4,600	27,600	500	25,900	51,300	337,000	327,000	336,000	178,200
Aero Research & Tech	1991	512,000	---	---	220	---	721	982	195,129	176,285	126,926	11,737
	1992	774,600	---	---	---	---	3,900	2,000	262,300	232,400	213,700	60,300
	1993	890,200	---	---	---	---	7,400	2,500	299,200	260,400	257,100	63,600
Space Research & Tech	1991	286,888	14,061	2,150	55,572	250	11,153	37,145	27,544	53,749	51,912	33,352
	1992	309,000	17,900	4,200	25,200	500	17,000	44,700	32,400	56,400	69,400	41,300
	1993	332,000	14,100	4,600	27,500	500	18,500	48,800	35,400	61,800	75,700	45,100
Transatmos Res & Tech	1991	95,000	---	---	122	190	---	---	2,726	8,824	3,737	79,401
	1992	20,000	---	---	100	---	---	---	3,200	7,900	3,100	5,700
	1993	80,000	---	---	100	---	---	---	2,400	4,800	3,200	69,500
Space Exploration	1991	0	---	---	---	---	---	---	---	---	---	---
	1992	0	---	---	---	---	---	---	---	---	---	---
	1993	31,800	15,300	---	---	---	---	---	---	---	---	16,500

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1993 ESTIMATES
DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA Hq
Tracking & Data Acqui	1991	20,000	---	---	---	---	5,600	13,990	---	---	---	410
	1992	22,000	---	---	---	---	6,200	15,400	---	---	---	400
	1993	23,200	---	---	---	---	6,200	16,500	---	---	---	500
Academic Programs	1991	55,100	1,496	790	1,413	885	2,075	996	1,555	1,320	1,347	43,223
	1992	66,800	2,038	1,226	3,091	1,210	2,010	1,746	1,692	3,820	1,947	48,020
	1993	71,400	2,218	1,416	2,294	1,490	2,090	1,876	1,822	2,576	2,161	53,457
Safety Reliability & QA	1991	33,000	2,707	2,011	2,509	310	2,518	6,791	480	1,910	2,765	10,999
	1992	33,600	2,780	1,785	2,780	605	3,695	4,820	125	1,890	4,275	10,845
	1993	32,500	2,260	1,925	1,895	860	3,270	4,389	271	1,665	3,480	12,485
TOTAL BUDGET PLAN	1991	6,023,522	1,161,735	210,292	966,059	16,540	1,153,016	649,292	349,951	279,441	554,493	682,703
	1992	6,850,756	1,353,754	283,619	1,047,166	24,393	1,127,342	750,843	443,042	344,565	656,271	819,761
	1993	7,731,400	1,507,435	364,017	1,178,578	32,329	1,252,664	743,531	500,248	380,135	771,383	1,001,080

SPACE STATION
FREEDOM

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT AND SPACE SYSTEMS DEVELOPMENT — SPACE STATION FREEDOM PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Development	1,790,700		2,022,900	2,200,000	RD 1-5
Flight telerobotic servicer	106,300		--	--	
Assured crew return vehicle	--		6,000	15,000	RD 1-19
Operations	--		--	35,000	RD 1-20
Advanced programs	3,000		--	--	
Total	1,900,000	2,028,900	2,028,900	2,250,000	

Distribution of Program Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	853,800		941,000	1,012,700
Kennedy Space Center	64,200		106,200	156,200
Marshall Space Flight Center	381,500		456,800	500,800
Stennis Space Center	--		--	--
Goddard Space Flight Center	108,000		--	--
Jet Propulsion Laboratory	7,600		3,900	2,900
Ames Research Center	1,700		600	100
Langley Research Center	3,600		2,900	2,000
Lewis Research Center	294,600		307,400	352,400
Headquarters	185,000		210,100	222,900
Total	1,900,000	2,028,900	2,028,900	2,250,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT AND SPACE SYSTEMS DEVELOPMENT — SPACE STATION FREEDOM PROGRAM

OBJECTIVES AND JUSTIFICATION

Development of the United States (U.S.) permanently manned Space Station, as directed by President Reagan in 1984 and reaffirmed by President Bush in 1989, is essential to preserving U.S. preeminence in space based science, technology and manned space flight. The Space Station Freedom (SSF) program is our opportunity to perform scientific and technological investigations, encourage commercial use of space, and gain direct experience in long-term human operations in space and knowledge essential to future space exploration. Space Station Freedom will permit us to study the effects of prolonged weightlessness on human physiology as well as develop effective countermeasures. It will serve as a testbed for the development of technologies for continuing human exploration of space and will be designed to evolve and be capable of growth in its capabilities so that future needs and challenges can be met. It is also the centerpiece of cooperation with our international partners, demonstrating the peaceful use of space for the benefit of all.

The SSF will be unique because it will provide the U.S. with a permanent outpost in space. Early in the flight program the SSF will provide an advanced research laboratory to stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to the storehouse of scientific knowledge. The Space Station's microgravity environment and extended time in-orbit will enable scientists to make new discoveries in materials research and life sciences. Perhaps the most significant feature of the Space Station, essential to its utility for science, commerce, and technology, is the continuing presence of its crews, and following the attainment of Permanently Manned Capability (PMC), men and women will be aboard the Space Station base full-time. The potential of humans-their resourcefulness and reactivity-is unique and essential. The Space Station will be designed to exploit these human capabilities.

The SSF will be a multipurpose, international facility. In 1984, President Reagan invited the full participation of other nations. During the ensuing definition phase, Canada, the European Space Agency (ESA), and Japan worked closely with the U.S. to define their participation. These parallel definition and preliminary design studies have resulted in the identification of the Space Station elements to be developed by our partners. Negotiations with these international partners for the development phase of the program were completed in the fall of 1988. Agreements have been signed with the Canadian government for the development of a mobile servicing system, with ESA for the inclusion of a pressurized attached module, and with the Japanese government for the development of an attached laboratory module. An agreement has also been signed in 1991 with the Italian Space Agency for provision of two mini pressurized logistics modules and potential provision of a Minilab in exchange for Italian use of the Space Station. In accordance with the terms of these agreements, the U.S. and the international partners will share the total available resources and the common costs for operations.

The program has incorporated the changes resulting from the restructuring activity directed by Congress in the fall of 1990. As a result of this activity, the Space Station Freedom has been simplified and annual funding levels have been reduced, while reductions in program capabilities have been kept to a minimum and commitments to the international partners have been maintained. The Space Station development funding supports the restructured man-tended phase and permanently manned capability (PMC) program including accommodations for the Office of Space Science and Applications (OSSA) 2.5 meter centrifuge. The Space Station design can accommodate a follow-on phase to support eight crew members and 75 kw of power. Because the modularity and inherent flexibility in the design has been maintained, Space Station Freedom can evolve in response to new user requirements and advances in technology.

Major restructuring changes include: shortened laboratory and habitation modules to allow more complete integration and checkout on the ground; truss segments and systems pre-integrated and checked out on the ground; reduced system complexities in the data management system, guidance, navigation, and control systems, and the environmental, control, and life support systems, reduced extravehicular activity times for assembly and maintenance; elimination of the Attached Payloads Accommodation Equipment (Work Package-3); and deferred operations capabilities. The SSF program's data processing and communications requirements have been simplified as a result of the restructuring activity. This simplified design will allow the Space Station Freedom to accomplish its major objectives as a life sciences and materials research facility in space, and will continue the tradition of U.S. preeminence in manned space flight.

Space Station operations encompasses activities required to maintain the Space Station for its planned lifetime. These activities include establishing an inventory of spares hardware, logistics support, crew training, mission operations, engineering support, launch processing, and user training and operations. Initial funding for this effort is included in the FY 1993 budget request.

In FY 1993, the SSF will complete the project level Critical Design Reviews (CDR) and conduct its system level CDR. As a result of the CDR, the detailed design of the man-tended Space Station Freedom systems and elements will be finalized. This will allow the hardware fabrication and assembly activities to continue. Current program plans support testing, integration and checkout of the flight hardware in preparation for the first element launch in the second quarter of FY 1996, the attainment of the man-tended capability (MTC) in FY 1997, and PMC in late FY 2000.

There have been few changes to the configuration since the restructuring activity last year. A third node has been added late in the PMC configuration to accommodate the 2.5 meter centrifuge planned by OSSA; and, a material science glovebox, deleted during the initial restructuring, has been reinstated in the PMC configuration. The development of a unique internal camera, and a global positioning system (GPS) capability have been deleted.

Similarly, there have been few changes in the restructured development funding and schedules. The impact of the proposed termination of the Shuttle's advanced solid rocket motor (ASRM) capability is still under review, but it is not expected to affect the achievement of the man-tended capability milestone. Because of the reduction in planned launch weight capability, preliminary analyses indicate that an additional two assembly flights would be necessary to complete the PMC configuration, and an additional utilization flight would be likely. Planned resources have been reduced and rephased, and the PMC target has been redefined for late FY 2000. Funding for assured crew return vehicle (ACRV) studies has also been allocated in FY 1992 and FY 1993 in order to examine a wide range of options for providing this capability as an expedient means of returning Space Station Freedom crewmembers to Earth during the permanently manned phase of the program.

Since the FY 1992 budget estimate was submitted prior to completion of the restructuring activity, no project or center estimates were available. Consequently, a comparison at those levels to the current FY 1992 estimates is not possible and has been deleted from the remaining budget summary.

BASIS FOR FY 1993 FUNDING REQUIREMENT

DEVELOPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Pressurized modules	371,200		433,500	448,400
Assembly hardware/subsystems	731,200		764,600	766,200
Platforms and servicing	2,800		--	--
Power system	292,800		306,500	350,400
Operations/utilization capability development	149,800		253,600	377,100
Program engineering and integration	242,900		264,700	257,900
Total	1,790,700		2,022,900	2,200,000

OBJECTIVES AND STATUS

As a research facility in space, the SSF will provide opportunities for significant advances in science, technology and commerce. It will be flexible yet durable in its capabilities, as the Station will be on orbit for many years. The objectives of the program are: (1) to establish a man-tended laboratory facility in low earth orbit in FY 1997, which will concentrate on research in a microgravity environment; (2) to establish permanently manned capabilities in late FY 2000 which will focus on life sciences research and have the capability to evolve to meet future requirements; (3) to enhance mankind's evolving ability to live and work safely in space; (4) to stimulate technologies of national importance by using them to provide needed capabilities; (5) to provide for effective operations and utilization of facilities for scientific, technological, and operational activities enabled or enhanced by the presence of man in space; (6) to foster mutually beneficial international cooperation in space; (7) to create and expand opportunities for private sector activity in space; and (8) to enable the evolution of the Space Station to meet future requirements and challenges. The combination of man-tended and manned automated systems will establish a broad spectrum of capabilities responsive to both currently identified and evolutionary needs of space science, technology, and commerce.

The major physical elements of the configuration to be developed by the U.S. include pressurized habitation and laboratory modules, with a shirt-sleeve environment for crew habitation and for conducting experiments under microgravity conditions; resource nodes linking the modules in which command and control, docking and extravehicular activity (airlock) functions will be based; high power solar arrays and power distribution; a truss structure featuring pressurized and unpressurized logistics elements. The configuration includes elements to be provided by the program's international partners. These elements are the Japanese experiment module, which includes a pressurized laboratory, an exposed module for payloads, and a logistics module; the Canadian Mobile Servicing System; and, the ESA's pressurized laboratory, polar platform, and man-tended free-flyer. It also includes the Italian provided mini pressurized logistics modules and could potentially include the minilab. At PMC, the Space Station will be able to support a crew of four and provide a total average power of not less than 56.25 kilowatts, using photovoltaic arrays.

The ground-based infrastructure needed for the development and operation of the Space Station includes systems engineering and integration capabilities, a distributed system for technical and management information transmission, software development tools, prelaunch processing, mission operations, engineering support, integrated testing, and payload operations support.

The responsibility to provide Space Station program policy and top-level technical direction resides at NASA Headquarters. The Space Station Freedom Program Office (SSFPO), located in Reston, Virginia, has the responsibility of managing and integrating the day-to-day technical development of the entire program. The three centers, who manage the hardware/software design and development and support system integration functions are the three work package centers: Marshall Space Flight Center (MSFC) in Huntsville, Alabama, Johnson Space Center (JSC) in Houston, Texas and Lewis Research Center (LeRC) in Cleveland, Ohio. The Kennedy Space Center (KSC) at Cape Canaveral, Florida and the Mission Operations Project Office (MOPO), located at JSC, play key roles in the development and implementation of Space Station operational capabilities. Langley Research Center (LaRC) also has a role in defining Space Station program requirements and conducting independent assessments.

NASA's development strategy for the Space Station deliberately precluded utilization of a single prime contractor. For a program of such extended duration as the Station, dependency upon one company was not viewed as being in the best interest of the government. Moreover, the work package approach better utilizes NASA expertise at the field centers and fosters greater competition among U.S. industry. An essential component of this strategy is that NASA will perform the overall systems engineering and integration and program management. The SSFPO is being assisted in these program-wide management integration functions by a Space Station Engineering and Integration contractor (SSEIC), a Technical and Management Information System (TMIS) contractor, and a Software Support Environment (SSE) contractor.

Grumman Aerospace and its team, as the SSEIC, has responsibility for supporting overall SSF engineering and integration activities. These responsibilities include: systems engineering and analysis, distributed systems integration, technical integration, element and launch package integration, user interface planning, and program management and control. The TMIS effort, contracted with Boeing Computer Services, facilitates both program control and engineering by enabling the electronic transmission of information and providing a means of distributing, maintaining, and archiving controlled data throughout the program. The SSE system, contracted with Lockheed Missiles and Space Company, is designed to assure a standardized software development and maintenance environment. This is to minimize the development and cost risk inherent in the task of integrating flight and ground systems software developed by a variety of Space Station contractors.

The Missiles and Space Division of Boeing Defense and Space Group, the Space Station Division of the McDonnell Douglas Space Systems Company and the Rocketdyne Division of Rockwell International are the work package prime contractors for the design, development and support of the components and systems comprising the Space Station.

The development program also includes critical supporting development activities at the three NASA work package centers, and the development of the capability to operate and utilize the Space Station. Work package supporting development includes design engineering, hardware integration and test capabilities, and assembly and checkout test capabilities; the provision of government furnished equipment (GFE); research and development (R&D) facility outfitting; and engineering management and analysis. These efforts support all of the work package prime contractors as well as overall NASA system engineering and integration efforts.

The Operations and Utilization Capability Development (OUCD) activities support major operational facility development and outfitting at the NASA work package centers and KSC. The facilities are critical to the integration, pre-launch/post-landing processing, and the missions operations and crew training for the Space Station.

The man-tended capability (MTC) phase preliminary design review (PDR) was completed successfully in November 1991. Detailed design of the SSF flight and ground hardware and software has begun. The program-level critical design review (CDR) is planned to occur in FY 1993. The first element launch is planned for second quarter FY 1996, man-tended capability (MTC) in the third quarter FY 1997, and PMC is planned late in FY 2000.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Pressurized modules-work package 1 Marshall Space Flight Center	371,200		433,500	448,400

OBJECTIVES AND STATUS

Work Package 1 is being managed by Marshall Space Flight Center (MSFC), Huntsville, Alabama with support from its prime contractor, Missiles and Space Division, Boeing Defense and Space Group. Boeing was awarded a letter contract on December 23, 1987, and signed a negotiated contract on September 28, 1988. Assisting Boeing as major members of the prime contract team are Teledyne Brown Engineering (Huntsville, Alabama), Lockheed Missile and Space Company (Sunnyvale, California), Hamilton Standard (Windsor Locks, Connecticut), AiResearch (Torrance, California), Grumman Aerospace Corporation (Houston, Texas), ILC Space Systems (Houston, Texas), Loral Fairchild Systems (Syosset, New York), Harris Corporation (Melbourne, Florida), Life Systems (Cleveland, Ohio), Perkin Elmer (Pomona, California), Ball Electro-optics (Boulder, Colorado), ILC Technology (Sunnyvale, California), TRW (Huntsville, Alabama), ARDE (Norwood, New Jersey) and Astro International (Houston, Texas).

Major components of this package include the U.S. laboratory, habitation, and logistics modules; node structures; airlock systems; environmental control and life support system; internal audio, video, and thermal systems; basic module outfitting; and associated software development.

With the completion of Space Station Freedom redesign activities in FY 1991, Work Package 1 has continued to build up their development test program. Extensive building modifications have been completed on-site at MSFC to support manufacture and testing of development, qualification, and flight articles. Tooling and manufacturing techniques have been validated through fabrication of parts for the pressurized module including the node radial port (including hatch, active rigid berthing mechanism, and common core window), and aft trunnion/longeron assembly. Composite demonstration racks have also been fabricated and outfitted on-site.

Extensive structural testing has been carried out to determine seal damage and window frame pressure tolerance, as well as aft trunnion static loads. Air flow, lighting and fire detection/suppression development tests have also been completed. Major milestones have been achieved in the environmental control and life support system (ECLSS) area, with the successful completion of recipient mode water recovery tests for hygiene and potable water. System level testing has been conducted using human test subjects to contribute respiration, perspiration, urine, and shower water to be processed for hand wash, shower, and drinking water. As testing of MTC hardware is completed, final design of those elements will be carried out in the current fiscal year, with critical design reviews scheduled early in 1993.

BASIS OF FY 1993 ESTIMATE

In FY 1993, final designs will be completed for the resource nodes, airlock systems, gas conditioning assembly, cupola, and laboratory module. Following the critical design reviews for those elements, work will begin on assembly and qualification testing. In support of **PMC**, preliminary design work will begin for the pressurized logistics module and the habitation element. Additionally, preliminary design reviews will be completed for the unpressurized logistics element, and the mini-pressurized logistics modules which are being provided by the Italian Space Agency.

The critical design review for distributed systems will also take place in FY 1993. Final drawings will be released for a number of critical **ECLSS** subsystems including atmosphere revitalization, atmospheric control and supply, fire detection and suppression, and regenerative water recovery and management for the laboratory element. **ECLSS** integrated redevelopment testing is scheduled for completion, and preparation for the next phase of integrated testing (Baseline System Test) will begin. In addition, intermodular ventilation testing for the MTC configuration will be completed, and efforts will be initiated to prepare for tests for the PMC configuration.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Assembly hardware/subsystems .... Work Package 2 Johnson Space Center	731,200		764,600	766,200

OBJECTIVES AND STATUS

Work Package 2 is managed by Johnson Space Center (JSC) with support from the prime contractor, the Space Station Division of the McDonnell Douglas Space Systems Company. The letter contract for this effort was awarded to McDonnell Douglas on December 23, 1987, and the negotiated contract was signed on September 28, 1988. Assisting McDonnell Douglas as major members of the contract team are IBM (Houston, Texas, Oswego, New York), Lockheed Missiles and Space Company (Houston, Texas, Sunnnyvale, California), General Electric (Camden, New Jersey), Honeywell (Clearwater, Florida), Astro Aerospace Corporation (Carpinteria, California), Sundstrand (Rockford, Illinois), and LTV (Dallas, Texas).

Work Package 2 responsibilities include the pre-integrated truss assembly, airlock structure and unique equipment, outfitting of the resource nodes, and the propulsion system. Also, included in Work Package 2 are the data management system; communication and tracking system; guidance, navigation and control system; extra vehicular activity system; thermal control system; mechanical systems; fluids management system, and utilities distribution.

Much of the effort taking place since the letter contract inception has been in formulating the plans, procedures, and design concepts that will be utilized for the development of the Work Package 2 elements and systems. Work is currently underway on the development of testbeds needed to evaluate design concepts, design and trade studies, facility requirements, and subsystem requirements. Major accomplishments include the completion of the Data Management System (DMS) Software First Article Configuration Inspection, completion of the Propulsion Development Test Article, completion of the Waste Gas Compressor, and completion of the Station Heat Pipe Advanced Radiator Element (SHARE) II flight experiment. Plans for the procedures, hardware, and software needed for on-orbit assembly are continuing and the Shuttle/Station berthing and docking concepts are being evaluated.

Currently, WP-2 is initiating the system level CDR's to support the program MTC CDR in FY 1993. Also ongoing is the design and development of the flight experiments that will be needed to test various concepts and hardware prior to their use in SSF. Flight experiments include Assembly of Station by EVA Methods (ASEM) (mid-1992) to evaluate assembly processes, and the Environmental Oxygen Interaction with Materials (EOIM-III) (late 1992) to evaluate the effects of atomic oxygen on SSF materials.

BASIS OF FY 1993 ESTIMATE

Activities will concentrate on the Critical Design Reviews (man-tended capability specific CDRs) for most of the elements and systems, such as the Guidance, Navigation, and Control (GNW), Extravehicular Activity System (EVA), Pre-Integrated Truss (PIT), Primary Propulsion System, Airlock, Crew Health Care System (CHeCS), Mechanical Systems, Data Management System (DMS), Thermal Control System (TCS), and Resource Nodes and Software. Qualification unit testing of the Communication and Tracking Video Subsystem will begin at the start of the fiscal year and the Development Verification Test Model (DVTM) for the video subsystem will be tested in the Electronic Systems Test Laboratory (ESTL). Also, the DVTM for the communication and tracking assembly contingency subsystem will be initiated and be completed in FY 1993. The first flight software for the Data Management System will be delivered. The fabrication, qualification and assembly tests for the Pump Module (PM) of the Thermal Control Systems Heat Transport Subsystem will be completed in FY 1993. Qualification unit fabrication testing for the Heat Rejection Subsystem will be completed. The GNW Inertial Sensor Assembly (ISA) development unit and qualification unit test will be completed. The GN&C star tracker hardware and software development unit will be completed and the navigation base will be qualified. The fabrication of the flight unit will be initiated. Qualification testing for the Control Moment Gyro (CMG) will be completed. The PIT static test article and development test articles will be fabricated and assembled. The 1-G test of the airlock mock-up will be performed. The EVA Service and Performance Checkout Unit Component and Subsystem fabrication and test will be completed. The fabrication, qualification, and assembly test for the Mobile Transporter Development Test Article will begin.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Power system - work package 4 .... Lewis Research Center	292,800		***306,500***	***350,400***

JECTIVE AND STATUS

Work Package *4* is managed by Lewis Research Center (LeRC) and supported by its prime contractor, Rocketdyne Division, Rockwell International (Canoga Park, California). Supporting Rocketdyne as major members of the contract team are: Space Systems/Loral (Palo Alto, California); Lockheed Missiles and Space Company (Sunnyvale, California), LTV Aerospace (Dallas, Texas), and Hamilton Standard (Windsor Locks, CT.). Rocketdyne was awarded a letter contract on December 23, 1987, and signed the negotiated contract on September 28, 1988.

The primary content of Work Package *4* is the SSF Electrical Power System. This encompasses a ***56.25* kw** photovoltaic (PV) power system, at PMC, which uses solar arrays to collect power and batteries for storage, as well as the associated power management and distribution system (PMAD).

The first PV Module is a key element of the First Element Launch of the Space Station. Subsequent PV Modules are scheduled to be launched in 1997 and 1998. Important PV subsystems include the beta gimbal, solar array, power thermal control system, batteries and the integrated equipment assembly. Each of these key subsystems must go through engineering model or mass thermal acoustic model buildup, qualification testing and fabrication/assembly and final test prior to final integration into a PV Module. The PMAD components undergo a similar development process and are delivered to other work packages for incorporation into their flight elements/systems. PMAD components include the Direct Current to Direct Current Converter Unit (DDCU), Main Bus Switching Unit (MBSU), Remote Power Controller Module (RPCM) and the Direct Current Switching Unit (DCSU).

Test beds for both photovoltaic power and the PMAD system have been developed and are being utilized for a variety of model development and qualification testing. Battery life testing is currently being conducted in the Power Systems Facility. Battery Charge Discharge Units (BCDU) and Direct Current Switching Unit (DCSU) breadboards, as well as the other PMAD components are being integrated and checked out in the Space Power Electronics Lab (SPEL).

BASIS OF FY 1993 ESTIMATE

The Critical Design Reviews (CDRs) for the Electrical Power System (EPS) and its Photovoltaic (PV) and Power Management and Distribution (PMAD) subsystems will be completed in the first quarter of FY 1993. With the maturation of the PV system design, the prime contractor will begin assembling and testing the engineering model of the Integrated Equipment Assembly (IEA), which includes the batteries as well as important switching units and battery charge/discharge units. Fabrication of the IEA qualification model will follow in the fourth quarter of the year. The prime contractor will also continue to assemble engineering and qualification models of the PMAD orbital replacement units (ORUs). The work on PMAD engineering models, begun in FY 1992, will continue in support of the PMAD components in the Electrical Systems Integrated Test (ESIT) program at the Space Power Electronics Laboratory (SPEL) and will begin soon after the IEA test.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Operations/utilization capability development	149,800		253,600	377,100

OBJECTIVES AND STATUS

The purpose of Operations/Utilization Capability Development (OUCD) is to develop a set of facilities, systems, and capabilities to conduct the operations of the Space Station Freedom. The majority of the work will be performed at KSC, MSFC, and JSC, although key operational capabilities will also be developed at other NASA centers. KSC will develop launch site operations capabilities for conducting prelaunch and post-landing ground operations. These capabilities will include the development of the Test, Control and Monitor System (TCMS) to provide real-time checkout, control and monitoring functions during processing of SSF elements at KSC prior to launch. Prelaunch and post-landing ground operations will occur in the Space Station Processing Facility (SSPF) and other key facilities, including the Space Station Hazardous Processing Facility (SSHPF) at KSC.

MSFC will develop user integration capabilities to establish user requirements and perform user operations support. Efforts will include the development of payload operations integration capability and the Payload Training Complex (PTC), as well as extensive payload mission planning and analytical integration. The major objective at JSC is to develop space systems operations capabilities for conducting training and on-orbit operations control of the SSF. Efforts will include the development of the Space Station Control Center (SSCC) and the Space Station Training Facility (SSTF). LeRC will provide the capability of engineering support for the power system. Each of these centers will be involved in user integration activities and operations planning efforts.

Work is currently underway to outfit facilities and to develop mission planning and user interfaces. The prime contractors associated with the work packages are assisting in the development of requirements since the design, development, and operation of the Station are so strongly interconnected. In addition, users and astronauts are involved in the OUCD planning efforts.

BASIS OF FY 1993 ESTIMATE

At JSC the Mission Operations Project Office (MOPO) will intensify their facility outfitting efforts in the SSCC and the SSTF. They also plan to support the critical design review, initiate evaluations of Data Management System (DMS) prototype hardware, and increase their efforts to support the SSCC interfaces with the engineering support centers (ESCs). At KSC a build-up in manpower is expected to provide for outfitting for the SSHPF and the SSPF. LeRC will maintain their support for the power systems Engineering Support Center. MSFC plans to complete the definition of requirements for the PTC and begin development. Effort will also increase in FY 1993 to develop the capability for payload operations integration.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Program engineering and integration ...	242,900		264,700	257,900

OBJECTIVES AND STATUS

Elements of the SSF are being designed and developed by NASA centers and contractors throughout the United States as well as by the Canadians, Europeans, Japanese, and their contractors. Coordinating and integrating all these various activities requires a comprehensive management and integration effort by the Space Station Freedom Program Office (SSFPO). Management responsibilities include: overall program management and direction; systems engineering, design, and integration management of technical and administrative information; systems software environment design and development; safety, reliability, maintainability, and quality assurance activities; and integration of the United States and international systems and elements.

The broad scope and large magnitude of the Space Station program requires that NASA be supported by contractors knowledgeable in overall systems design, engineering, and integration. To achieve this goal, NASA awarded an engineering and integration contract to Grumman Aerospace Corporation. As the Space Station Engineering and Integration Contractor (SSEIC), Grumman has responsibility for supporting overall Space Station systems engineering and integration activities. Grumman supports the SSFPO in Reston, Virginia, and the system integration activities at the work package centers and KSC. This includes providing the engineering manpower necessary for total systems configuration analysis and integration, design trade-offs, and operational analyses. They also assist in evaluation of technical performance across the program and perform program schedule integration. They develop technical plans and procedures for the verification, assembly, and integration of the overall Space Station system and assist in the assessment of hardware/software systems developed by the work package prime contractors. During FY 1992, Grumman will play a significant role in all of the activities necessary for preparing and supporting main program design reviews. The program system integration continues to be supported by **a** System Integration Office at Johnson Space Center (JSC), an Element Integration Office at Marshall Space Flight Center (MSFC), and an Electrical Power Integration Office at Lewis Research Center (LeRC). These offices are managed by the SSFPO utilizing on-site personnel including Grumman.

Implementation of a program-wide technical and management information system (TMIS) is a significant part of the management and integration activity. The size and complexity of technical and management information that must be shared across all elements and levels of the program requires the development of an advanced information system that can expeditiously handle the flow of these data. Boeing Computer Services was awarded a systems integration contract to provide the official repository of technical and management information. It provides a common methodology for tracking, updating, and disseminating among all the participating NASA centers and contractors. It will also allow NASA to electronically transfer appropriate program data to compatible information systems of the international participants. Development of data bases and maintenance of existing hardware and software continues as the program milestones for various design reviews evolve.

Another important component of the management and integration effort is the design, development, and application of compatible flight and ground support software. To ensure compatibility across the various elements of the Space Station information system, NASA awarded a contract to the Lockheed Missiles and Space Company for the development of a software support environment (SSE). Lockheed is tasked to develop the software tools, rules, and standards that will be common to all Space Station flight and ground support users in their software development efforts. SSE has developed the initial SSE development facility which is providing basic software life cycle support capability. Five software production facilities are in place at the work package sites supporting their software development activities.

BASIS OF FY 1993 ESTIMATE

During FY 1993, the Space Station Engineering and Integration Contractor (SSEIC) will continue to concentrate on the overall integration of the Space Station Freedom Program design activities as the program emerges from its critical design phase. Emphasis will be placed on integrating program advance plans and schedules, management of major Space Station resources (weight, power, volume, thermal, etc.) and identification and resolution of design issues. SSEIC will assess the adherence to requirements and design criteria of the program from a stage perspective at all program reviews to ensure the end-to-end system performance, element functionality and spacecraft unique features are incorporated into the evolving design. SSEIC will support the oversight for the implementation of the program verification process; documenting, assessing, and integrating requirements, plans, criteria, and schedules. SSEIC will further support those centralized functions required to verify integrated flight software and validate integrated software and avionics performance. Other critical work will include update of program design and verification requirements, stage configurations, interface definitions, stage performance assessments and numerous other program design definition products required for review at both the MTC and PMC Phase Critical Design Reviews (CDRs). SSEIC will also provide plans and support for the various Level II and Level III reviews to be conducted in FY 1993.

TMIS will continue to incrementally deliver its products and will work closely with all levels of the program to assure the most efficient and comprehensive exchange of information. Efforts will continue to maintain the various bridges needed to electronically link together the contractors, NASA centers, users, and international partners as well as provide training to TMIS users as the system evolves. Technical and resource information management, tracking systems and data bases will continue to be developed with emphasis on the efforts needed to support the program CDR process. Future increments will focus on designing required operational data bases and integrating existing data bases into TMIS. The computer integrated engineering (CIE) capability for the program is operable and considerable effort will be required to prepare the engineering data bases with current information to support the program's design reviews.

The SSE will build upon its initial operational capability by increasing and improving existing capabilities in the Software Support Environment Development Facility (SSEDF). The software production facilities at the field sites will be supported and additional facilities put in place as requirements dictate.

BASIS OF FY 1993 FUNDING REQUIREMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Assured crew return vehicle	--		6,000	15,000

OBJECTIVES AND STATUS

Funding is provided for detailed design, schedule, and cost studies for an Assured Crew Return Vehicle (ACRV). NASA will examine a wide range of options for providing this capability as an expedient means of returning Space Station Freedom (SSF) crewmembers to Earth during the permanently manned phase of the program. In addition to the ACRV studies, an independent panel (the Aerospace Safety Advisory Panel), will review the justification and requirements for an ACRV in anticipation of a decision on whether to proceed with development.

The ACRV will provide the on-orbit standby capability and pre-coordinated ground support to ensure adequate safety for the SSF crew members under those conditions necessitating a response that cannot be accommodated by the Space Shuttle or by the onboard emergency management system. The ACRV system will provide the capability to return crew to Earth from the SSF in case of (1) an ill or injured crewmember, (2) an accident or system failure which requires immediate departure, or (3) interruption of Space Shuttle flights in support of crew rotation. The Phase A requirements validation was completed September 30, 1990, and was funded by the Office of Space Flight Advanced Programs. Program engineering and integration studies were performed in FY 1991 in order to assess subsystem redundancy issues relating to the restructuring effort.

In order to support the attainment of PMC in FY 2000, definition of the ACRV preliminary design, schedule, and cost estimates will be initiated with Phase B studies in FY 1992. Previous Phase A studies indicate that after definition, five to six years of development will be required for completion and testing of the first unit; the preliminary cost estimates for a three-vehicle system indicate a probable cost range of $2-3 billion in real year dollars, including Construction of Facilities requirements. Phase B studies will identify potential cost reduction areas and a more definitive estimate based on an improved level of design definition.

BASIS OF FY 1993 ESTIMATE

Definition of the ACRV preliminary design, schedule, and cost estimates will continue throughout FY 1993 and will be targeted for completion in FY 1994.

BASIS OF FY 1993 FUNDING REQUIREMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Operations	--		--	35,000

OBJECTIVES AND STATUS

Planning for operations and utilization has been an integral part of the SSF design and development program and a major driver in the approaches established for Station assembly, utilization, and evolution. As a long-term permanently manned laboratory in orbit, Freedom will be serving the needs of many disciplines and individuals, and must be designed and operated to be safe, reliable, and accommodating to numerous diverse users. It must also be amenable to changes in technology that will be occurring during its planned thirty years in space. The various elements of the development program such as flight systems hardware/software production, operations/utilization capability development, and management and integration will transition, over time, into the components of the operations program. These components include flight and ground hardware and software sustaining engineering, integrated logistics support, user integration and operations support, space system operations support, prelaunch and post-landing operations, and information systems services operations. In addition, the Space Station Science Utilization Management (SUM) activity, previously planned by OSSA, has been transferred to the Space Station's budget. The various elements of this activity include payload support for the user community, physical integration support of payloads, and integrated science operations.

BASIS OF FY 1993 ESTIMATE

Although low level planning for operations has been ongoing within the development program under operations/utilization capability development, FY 1993 is the first year that major funding is required for items that are included in the operations budget of the program. During FY 1993, initial lay-in of spares, along with procurement of long-lead items required to be in place to support First Element Launch (FEL) for work packages, will be initiated. Flight hardware spares procurement will include propulsion tank components and forgings; thermal components; guidance, navigation, and control (GN&C) wheel casting; electrical, electronic, and electromechanical (EEE) parts; and communication and tracking (C&T) space-to-ground equipment. GSE spares will be procured for the hydrogenic servicer, ammonia servicer, and test control and monitor system (TCMS) Serial 0 system and the nitrogen/helium equipment. Logistics activities will also focus on logistics management and maintenance planning for initial spares for flight hardware and support equipment. Science utilization management activities will include performing initial payload analytical integration activities and continued planning for the Integrated Science Operations Center at Marshall Space Flight Center and the Payload Integration Center at Kennedy Space Center.

SPACE
TRANSPORTATION
CAPABILITY
DEVELOPMENT

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICES OF SPACE FLIGHT AND SPACE SYSTEMS DEVELOPMENT — SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Spacelab	129,300	150,200	96,000	122,600	RD 2-4
Upper stages	82,467	108,500	62,256	(56,500)*	RD 2-7
Engineering and technical base (ETB)	208,500	235,200	215,800	224,200	RD 2-9
Payload operations and support equipment	101,200	144,500	119,100	153,600	RD 2-11
Advanced programs	35,200	53,800	39,300	57,700	RD 2-13
New launch system (NLS)	23,900	175,000	38,000	125,000	RD 2-16
Tethered satellite system (TSS)	21,900	12,600	16,400	3,400	RD 2-18
Research operations support	(169,047)**	(190,844)**	144,600	177,200	RD 2-19
Total	602,467	879,800	731,456	863,700	

*A non-add. Beginning in FY 1993, Upper Stages will be funded under the SFCDC/Expendable Launch Vehicles.
**A non-add. Funded as Operation of Installation in the Research and Program Management (R&PM) appropriation.

Distribution of Program Amount By Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	196,300	248,600	262,400	302,400
Kennedy Space Center	121,500	127,800	148,500	173,900
Marshall Space Flight Center	247,100	418,200	242,100	298,000
Stennis Space Center	9,300	24,800	15,800	22,900
Goddard Space Flight Center	12,400	14,400	11,400	9,900
Jet Propulsion Laboratory	700	400	300	400
Langley Research Center	2,000	1,100	1,100	700
Lewis Research Center	1,900	29,200	900	500
Headquarters	11,267	15,300	48,956	55,000
Total	602,467	879,800	731,456	863,700

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

OFFICES OF SPACE FLIGHT AND SPACE SYSTEMS DEVELOPMENT **SPACE TRANSPORTATION PROGRAM**

(JECTIVES AND J1

The principal areas of activity in Space Transportation Capability Development includes the operation of the Spacelab systems with some continuing development activities; procurement of Upper Stages required to place satellites in high altitude orbits; the maintenance of an Engineering and Technical Base capability at the manned space flight centers; Payload Operations and Support Equipment for accommodating NASA payloads; Advanced programs study and evaluation efforts; New Launch System efforts including definition and preliminary development of a new launch vehicle capability with improved propulsion technology; completion of the design and development of the United States/Italian Tethered Satellite System; and Research Operations Support which was previously funded as Operation of Installation under the Research and Program Management (R&PM) appropriation.

Spacelab and the Spacelab carrier systems were developed jointly by NASA and the European Space Agency (ESA). The Spacelab is a major element of the Space Transportation System (STS) that provides a versatile, reusable laboratory which is flown to and from Earth orbit in the orbiter cargo bay. The Spacelab carrier systems also include pallets which provide payload mounting and support services (pointing, computer control, data processing, power, cooling, etc.) for attached payloads. The Spacelab and carrier systems development continues with a recertification program to insure flight safety, hardware procurement to support the flight program, and necessary upgrading of obsolete hardware to current technology. As in the past, Spacelab requirements are funded through a combination of appropriations and reimbursements received from customers.

Upper Stages are required to deploy payloads to orbits and trajectories not attainable by the Shuttle or Expendable Launch Vehicles (ELVs) alone. The program provides for procurement of stages for NASA missions, for technical monitoring and management activities for government and commercial Upper Stages, and a Solid Propulsion Integrity Program (SPIP) to improve the technical understanding and the engineering capability for solid rocket motors. Beginning in FY 1993, the continued procurement of Upper Stages will be included within the ELV budget under the Space Flight Control and Data Communications (SFCDC) appropriation since they directly support either a Shuttle or an ELV payload. The SPIP will be funded under Advanced programs beginning in FY 1993.

The Engineering and Technical Base provides a core level research and development capability for the engineering, scientific, and Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA) support required by a wide variety of NASA programs at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the Stennis Space Center (SSC). Additional requirements above the core level of capability are funded by the benefiting programs.

Payload Operations and Support Equipment program develops and places into operational status the ground and flight systems necessary to support NASA Shuttle payloads during prelaunch processing, on-orbit mission operations and, when appropriate, post-landing processing. Included within this program area are the unique requirements for individual NASA payloads to utilize the Shuttle, integration activities for the Shuttle and Space Station Freedom (SSF) including development of a berthing system, and multimission payload support equipment.

Advanced programs conducts concept feasibility studies, selected system definitions and preliminary design (Phase B) studies, and undertakes related high leverage advanced development to provide the technical and programmatic data to identify evolving space transportation and system requirements and to evaluate new technology capabilities. Complementary objectives are to assimilate generic technology and advanced planning activities, and to provide an advanced planning programmatic link between the Office of Space Systems Development and other NASA program offices. Activity is focused on four major areas: advanced transportation, advanced operations support, advanced space systems, and New Launch System (NLS) related efforts. Concept definition and key advanced development are underway and planned in these areas to assess performance, reliability and operational efficiency improvements, and to reduce future program risks and development costs through the effective use of new technology. Beginning in FY 1993, Advanced programs will include the SPIP.

The NLS is a joint program with DOD to develop a new family of launch vehicles. The goal of this program is to greatly improve national launch capability with reductions in operating costs and improvements in launch system reliability, responsiveness, and mission performance. Several NLS configurations with a range of capabilities will be developed, and an evolutionary path will be maintained to support options for further growth and technology improvements. The initial NLS program emphasis is on development of the Space Transportation Main Engine (STME).

The Tethered Satellite System (TSS), a joint United States/Italian development effort, will provide a new capability for conducting space experiments and unique tethered applications in regions remote from the Shuttle orbiter. The objectives of the initial TSS mission are twofold: (1) to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to quantify the interaction between the satellite/tether and space plasma in the presence of a current drawn through the tether.

Research Operations Support funding provides vital support to the civil service workforce and to the physical plant at the centers and at NASA Headquarters. This activity was previously funded as Operation of Installation in the R&PM appropriation.

BASIS OF FY 1993 FUNDING REQUIREMENT

SPACELAB

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Development	22,600	30,000	33,200	19,800
Operations	106,700	120,200	62,800	102,800
Total	129,300	150,200	96,000	122,600

OBJECTIVES AND STATUS

The Spacelab is a versatile facility designed for installation in the cargo bay of the orbiter which affords scientists the opportunity to conduct scientific experiments in the unique environment of space. The reusable Spacelab system enhances the advancement of scientific research by serving as both an observatory and laboratory in space. Ten European nations, including nine members of the European Space Agency (ESA), have participated in this joint development program with NASA. The ESA designed, developed, produced, and delivered the first Spacelab hardware consisting of: a pressurized module and unpressurized pallet segments, an igloo which is used with pallets to supply services essential to the experiments, an instrument pointing subsystem (IPS), and much of the ground support equipment and software for both flight and ground operations.

NASA procured an additional set of Spacelab hardware from ESA under terms of the ESA/NASA Memorandum of Understanding and the Intergovernment Agreement. The remaining development activities include additional hardware to complete the Spacelab carrier system, ground support equipment, hardware modifications, hardware acquisition, system recertification, and modified or improved hardware to expand the Spacelab capabilities and ensure its continued operational availability. Support software and procedures development, testing, and training activities not provided by ESA, which are required for the Spacelab, are also included in NASA's funding. Additional Spacelab hardware, including spare hardware, is being procured from European and U.S. sources as needed to support the flight manifest.

NASA has developed *two* principal versions of the Spacelab Pallet System (SPS). One will support missions requiring the igloo and pallet in a mixed cargo configuration like the Astro mission; the othet version, the Enhanced Multiplexer/demultiplexer Pallet (EMP), will support missions that do not require use of the igloo such as the Lidar In-space Technology Experiment (LITE), the Space Radar Laboratory (SRL), and the Tethered Satellite System (TSS).

The Spacelab operations budget includes mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, system operations support, payload operations control support, payload processing, logistical support and sustaining engineering.

The Astro-1, supported by an Igloo Pallet and Instrument Pointing System (IPS), was launched on a successful ultraviolet astronomy mission in December 1990. It was the first Spacelab mission to fly since Challenger. Two additional missions utilized Spacelab carriers in FY 1991, one a module mission (Space Life Sciences Laboratory-(SLS-1)) and one hitchhiker which supported several DOD experiments. In FY 1992, three Spacelab module missions are planned which are the first International Microgravity Laboratory (IML-1), the U.S. Microgravity Laboratory (USML-1), and the partially reimbursable Japanese Spacelab mission (SL-J). In addition, an igloo/pallet mission called the Atmospheric Laboratory for Applications and Science (Atlas-1) will also be flown. Along with these major missions are numerous smaller Spacelab carriers such as hitchhikers, getaway specials, and mission peculiar experiment support structures (MPESS).

In addition to the support of these missions, analytical and physical integration, configuration management, and software development for future flights will be conducted. Procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue throughout FY 1992 and FY 1993 as will operation of the depot maintenance program.

In FY 1992, NASA plans include $7.1 million of reimbursements which, together with the reprogramming of $24.0 million of unobligated balances from the cancelled Orbital Maneuvering Vehicle (OMV) project will sustain Spacelab operations funding requirements. In FY 1993, NASA will release $3.0 million of reimbursements received from Spacelab customers.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The $54.2 million decrease is partially accommodated by the transfer of unobligated funds from the termination of the OMV. The balance of the reduction is achieved through operations efficiencies imposed on the Spacelab program as well as holding potential changes to an absolute minimum which will constrain operational capability to support unique payload requirements.

BASIS OF FY 1993 ESTIMATE

The FY 1993 development funds are required to maintain or enhance program capabilities to support payload requirements. Funding includes replacement of obsolete hardware such as the Data Display Units (DDUs) which failed on the Astro-1 mission and unit testers necessary to support the operational checkout of Spacelab systems prior to flight. Funds are also included for automatic test equipment, refurbishment of the Software Development Facility at the MSFC, and upgrade of the Mass Memory Unit (MMU).

FY 1993 operations funds reflect the program requirements to conduct Spacelab missions consistent with the latest manifest. Missions to be flown in FY 1993 include the partially reimbursable German mission (SL-D2), the Atmospheric Laboratory for Applications and Science (Atlas-2), and the SLS-2. Two new missions have been added to the Spacelab manifest since the previous budget and they are Astro-2 and the LITE II scheduled for launch in FY 1994 and FY 1995 respectively.

BASIS OF FY 1993 FUNDING REQUIREMENT

UPPER STAGES

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Development	--	--	--	--
Procurement and operations...............	82.467	108.500	62.256	(56.500)*
Total..................................	82.467	108,500	62.256	(56.500)*

*A non-add. Funded under the SFCDC/ELV budget beginning in FY 1993.

OBJECTIVES AND STATUS

Upper Stages are required to deploy payloads to orbits not attainable by the Shuttle or a core stage expendable launch vehicle (ELV) alone. The Inertial Upper Stage (IUS), the commercially developed Transfer Orbit Stage (TOS), and the Centaur upper stage are included in this line item.

The IUS was developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. The IUS has been launched from the Shuttle, the Titan 34-D and Titan IV ELVs. The IUS stages are being procured for TDRS-6 and TDRS-7 which are scheduled to be launched on the Shuttle in FY 1993 and FY 1995 respectively. The IUS vehicle for TDRS-6 has been delivered. The Air Force has contracted for long lead hardware for the TDRS-7 vehicle as part of a planned three vehicle procurement with two DOD missions (Defense Support Program satellites (DSPs)).

The TOS is a three-axis stabilized perigee stage that is being developed commercially by the Orbital Sciences Corporation for use with the Shuttle and the Titan 111. It will have the capability to place 6,000 to 13,000 pounds into geosynchronous transfer orbit. A TOS/Titan III and a TOS/Shuttle upper stage are being procured for the Mars Observer (MO) and the Advanced Communications Technology Satellite (ACTS) missions to be launched in FY 1992 and FY 1993 respectively.

The Centaur upper stage has been modified for use with the Titan IV under a DOD contract. NASA funding will procure a Centaur stage to support the launch of the Cassini mission in October 1997. Since this stage is planned to be purchased along with the Titan IV as part of a DOD procurement, starting in FY 1993 its funding will be included under the ELV budget.

The Solid Propulsion Integrity Program (SPIP) objective is to establish the necessary engineering capability for improving the success rate of U.S.-built solid rocket motors. The program has made excellent progress in determining root causes and solutions to persistent problems plaguing motor nozzles and bondlines. The program is successfully moving the industry toward solid motors that have an improved basis in science and engineering. The program results are being used across the solid rocket motor community, including the Redesigned Solid Rocket Motor and DOD solid motor programs. Starting in FY 1993, funding for this program will be included in the Advanced programs budget.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Funding for Upper Stages is reduced $46.2 million. This is the result of the delay of the Cassini launch to October 1997, a reduction to the SPIP program, the Congressional action to remove funding for an option to procure additional TOS vehicles, and reestimates lowering the costs to maintain the capability to fly IUS stages on the Shuttle.

BASIS OF FY 1993 ESTIMATE

Beginning in FY 1993, Upper Stages will be included under the SFCDC/ELV budget line item consistent with the operational nature of their requirements. The SPIP will be funded under Advanced programs beginning in FY 1993.

BASIS OF FY 1993 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Research and test support	136,900	148,700	142,200	148,000
Data systems and flight support	18,200	23,800	18,200	17,300
Operations support	37,800	46,700	40,000	42,900
Launch systems support	15.600	16.000	15.400	16.000
Total	208.500	235.200	215,800	224.200

OBJECTIVES AND STATUS

The Engineering and Technical Base (ETB) provides the core capability required to sustain an engineering and development base for various NASA activities at the Office of Space Flight centers. Additional requirements above the core level are funded by the benefiting programs, such as the Shuttle or the Space Station Freedom (SSF). The centers involved are the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the Stennis Space Center (SSC).

The ETB is divided into four components which are research and test support, data systems and flight support, operations support, and launch systems support. Research and test support covers the Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) oversight functions at JSC, KSC, and MSFC. Operation of the Class VI computer facilities at JSC and MSFC is funded as well. The first shift of support needed to operate the engineering laboratories at JSC is covered along with the science and engineering support for the propulsion and engineering laboratories at MSFC. Data systems and flight support provides for operation of the Central Computer Facility and Center Information System at JSC. Operations support is primarily the maintenance and operations of various facilities and equipment at JSC and MSFC. Operations funding also provides some institutional support at the White Sands Test Facility and the Stennis Space Center. Finally, launch system support provides a core capability for engineering, scientific, and technical support for research and development activities at KSC.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The total funding for ETB has decreased $19.4 million in FY 1992 from the requested level as the result of general Congressional reductions. This will eliminate planned increases for support of basic research and development facilities and services at the manned centers. Engineering and SRM&QA manpower at JSC, KSC and MSFC has been constrained to FY 1991 levels. Engineering laboratory equipment purchases at JSC and MSFC have been significantly reduced. The limits on engineering manpower, equipment, and services at JSC and MSFC will constrain the support available to ongoing programs.

BASIS OF FY 1993 ESTIMATE

Overall ETB funding in FY 1993 will remain at the FY 1992 levels plus escalation. The requested funding for ETB in FY 1993 provides basic support for research and development facilities and services at the centers to meet critical requirements for support to the Shuttle, SSF, and other space transportation activities that have expanded their requirements significantly over the past several years. The ETB funding will continue to provide the core capability for SRM&QA requirements, maintaining the engineering labs and engineering support services, and a limited replacement of obsolete multipurpose lab equipment.

In research and test support, funding in FY 1993 will continue to support computational capabilities at MSFC for engineering and science projects through the use of a Class VI computer system. This capability is required for the solution of more complex main engine three-dimensional dynamics modeling problems and for complex structural analysis. At JSC, the requested funding in FY 1993 will provide for operation of the engineering and development laboratories, such as the Electronic Systems Test Laboratory, the thermo-chemical area, and SRM&QA activities, as well as a full-up operation of the Class VI computer system. The computer will be used to obtain numerical solutions of very large sector materials for the aerodynamics, thermodynamics, and structural mechanics analysis associated with developing and operating manned and robotic space systems.

Operations support will continue in FY 1993 to provide for the maintenance of multi-program research and development facilities and equipment, chemical cleaning, engineering design, technical analysis, component fabrication, and logistics support. Examples of specific services to be provided in FY 1993 include: (1) operation and maintenance of specialized electrical and cryogenic systems; (2) operation of shops to do metal refurbishing, anodizing, plating, stripping, and etching of selected items of in-house hardware; (3) engineering, installation, operation, and maintenance of closed circuit fixed and mobile television required for the support and surveillance of tests; (4) mission imaging services, including audiovisual mission support; (5) fabrication of models, breadboards, and selected items of flight hardware; and (6) technical documentation services. In FY 1993, MSFC will continue to provide for automatic data processing equipment, software, and programming support, data storage requirements, and improve response time to users. At White Sands, support will be provided for environmental compliance activities.

Both data systems and flight support at JSC as well as launch systems support at KSC will continue at their present level of activity.

BASIS OF FY 1993 FUNDING REQUIREMENT

P LOAD TIONS AND SUPPORT EQUIPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Payload operations	76,700	119,400	96,500	131,300
Payload support equipment	24.500	25.100	22.600	22.300
Total	101.200	144.500	119.100	153.600

OBJECTIVES AND STATUS

The objectives of the Payload Operations and Support Equipment budget are to provide payload services which are required beyond the standard Shuttle services for NASA missions, and to provide reusable support equipment for all payload operations. Payload operations provides unique hardware, analyses, and launch site support services for NASA missions. A significant part of the total funding directly supports integration activities for the Space Station Freedom (SSF) and Shuttle which includes development of a berthing system between the orbiter and the SSF. Payload operations also provides for the maintenance and operation of the Payload Processing Facilities (PPFs) at the launch site; unique analysis, planning, and services to allow payloads to achieve maximum scientific and mission objectives; and payload-unique hardware to interface with the standard Shuttle payload accommodations. The payload support equipment budget funds the development and acquisition of reusable ground support equipment required for a wide range of payloads. This includes test equipment required to checkout payload-to-orbiter interfaces at KSC, mixed cargo hardware such as standard cable harnesses, and displays and controls related to payload bay operations.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Payload operations and support equipment funding has decreased $25.4 million from the budget estimate due to a rephasing of SSF integration tasks, including berthing system development, to be consistent with the SSF milestones. In addition, estimates for payload optional services have been reassessed based on the latest Shuttle manifest.

BASIS OF FY 1993 ESTIMATE

Payload operations funding is required to support payload services and mission unique integration for scheduled NASA missions. The single largest area of support in FY 1993 is for SSF integration with the Shuttle. Funding is to start development of a berthing system which will support the SSF assembly beginning with flight MB-2 (the second assembly flight in FY 1996), to procure two additional Extravehicular Mobility Units (EMUs), to develop Extravehicular Activity (EVA) hardware for assembly operation, and to develop interface control requirements and supporting hardware. Other major NASA missions receiving support in FY 1993 include the Tracking and Data Relay Satellite System (TDRSS) and the Atmospheric Laboratory for Applications and Science (Atlas).

Payload support equipment estimates reflect the development, testing, and delivery of payload accommodation equipment and capabilities common to multiple NASA missions. A major category is the communications equipment necessary for payload data transmission during ground processing and checkout. This includes fiber optic cabling and an upgraded operational intercom system in the industrial area at the Kennedy Space Center (KSC) to provide increased flexibility and quality of data transmission among the various payload facilities. Orbiter/payload interface hardware for hitchhiker, cargo bay cabling, modified aft flight deck panels, and associated displays and controls are also included.

Increases required in FY 1993 over FY 1992 levels are related to the pace of the development activity associated with the berthing system and other SSF integration tasks.

BASIS OF FY 1993 FUNDING REQUIREMENT

ADVANCED PROGRAMS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Advanced transportation	12,500	11,600	9,500	10,300
Advanced operations	11,100	12,500	8,600	12,100
Advanced space systems	11,600	14,700	11,700	13,300
New launch system (NLS)	--	15,000	9,500	10,000
Solid propulsion integrity program (SPIP)	(14,800)*	(17,300)*	(10,100)*	12,000
Total	35,200	53,800	39,300	57,700

*Included in Upper Stages prior to FY 1993.

OBJECTIVES AND STATUS

The principal objectives of Advanced programs are to conduct definition studies and selected advanced developments to support future new development programs, system improvements and expanded capabilities for space transportation systems. The definition studies include concept definitions, selected system definition and preliminary design studies, and key advanced development addressing requirements for increased reliability, cost effectiveness, and capability of space flight systems. Information from these studies will support decisions on the best alternatives for developing capabilities required to support future mission options. High leverage advanced development efforts will be conducted to reduce future program development risks and costs through the effective application of new technology. A complementary objective is to coordinate advanced planning efforts between the Office of Space Systems Development and other NASA program offices.

The Advanced program effort is focused on five major areas: advanced transportation, advanced operations, advanced space systems, New Launch System (NLS) concept studies, and the Solid Propulsion Integrity Program (SPIP) effort. Advanced transportation activities include systems analysis and concept definition of launch vehicles as well as some advanced development activities to demonstrate promising technologies. Studies will be continued on concepts for a new transportation system, advanced fully reusable manned vehicles, cargo return vehicles, and other advanced transportation systems. The advanced development activity will address such high payoff areas as electrical actuators, advanced guidance, navigation and control (AGN&C), vehicle health management (VHM), and aluminum-lithium fabrication techniques.

The advanced operations program continues the pursuit of its goal of improving the ground and mission operations efficiency of the Shuttle through the introduction of advanced technologies into the operations environment. During FY 1991, additional development projects were integrated into Shuttle operations, including a complete Launch Processing System operations analysis and remote maintenance expert system in the Shuttle Launch Control Center, a new system to detect leaks during engine testing at the Stennis Space Center (SSC), and an automated method of validating and documenting Shuttle flight software at the Johnson Space Center (JSC).

The advanced space systems program includes concept definition, advanced hardware development, or flight experiments in the following areas: flight demonstrations, orbital debris, advanced concepts, and tether applications. The flight demonstrations are directed at supporting space flight development objectives as well as training young NASA engineers and managers with "hands-on" flight hardware experience. In FY 1991, significant progress was made in measurement of the orbital debris environment using groundbased radar. At the conclusion of the first phase of this program, the uncertainty in our estimates of the orbital debris environment is expected to be reduced from 300 percent to 57 percent. Transportation-related tether applications studies continue to define and implement flight experiments and demonstrations including orbital altitude changes without the use of propellants and tether-initiated recovery systems for the immediate or emergency return of small payloads from space. Testing was completed on a flight deployer in FY 1991 for a Small Expendable Deployer System. This system will enable the demonstration of a tether-initiated deployment on a Delta-II expendable rocket as a secondary payload scheduled for flight in FY 1993.

Efforts related to the New Launch System (NLS) include developing specific vehicle man-rating requirements, assessing alternate approaches to booster propulsion, studying automated rendezvous and docking concepts and technologies, and identifying requirements for the cargo transfer vehicle and upper stages. Also, the program will assess options and technologies for long-term evolution/growth of NLS vehicles to support potential future requirements, such as manned exploration missions.

The SPIP was established in 1985 to enhance the nation's engineering data base for solid rocket motors in order to improve their success rate. This improved reliability is coming about as a result of developing and validating data bases and engineering tools for motor design, margins and performance analysis, reproducible fabrication and processing, verification, and as a result of improving the culture across the nation's solid rocket motor infrastructure.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The current estimate reflects a net reduction of $14.5 million. This reduction was accommodated by reducing NLS studies and deferring planned development activities across all functional areas.

BASIS FOR FY 1993 ESTIMATE

In FY 1993, major program emphasis will continue to be placed on concept definition, system definition, and advanced development for advanced space transportation, advanced operations support systems, advanced space systems, and NLS activities. Also beginning in FY 1993, the SPIP will be funded under this budget line.

Funding for studies and technology efforts in the advanced transportation area will continue in FY 1993 including two-way personnel transportation systems and other advanced development activities including adaptive guidance, navigation and control, electromechanical actuators, vehicle health management, and the fabrication techniques for advanced structural materials.

Advanced operations efforts will continue to emphasize the identification and demonstration of technologies to improve efficiency, flexibility, and reliability of current and future space transportation systems. Included in advanced operations is the selective application of expert systems, automation, and other technologies to labor-intensive and hazardous operations. Launch processing systems, mission control applications, flight planning, training, simulation and other environments will be targeted to demonstrate emerging technologies for improving ground and flight operations.

Advanced space systems emphasis will be placed on autonomous and EVA hardware, systems and techniques which enhance on-orbit operations. Flight experiments, such as the Superfluid Helium On-Orbit Transfer (SHOOT) and Dextrous End Effector, will demonstrate enabling technologies in the space environment. Detailed engineering studies will continue to focus on promising concepts of transportation-related tether applications. Critical enabling tether-related technology will be demonstrated utilizing small flight experiments. Orbital debris activities are focused on characterization of the debris environment at Low Earth Orbit (LEO), establishing measures for mitigation of debris growth trends, and spacecraft protections techniques.

In support of the NLS, concept definition and advanced development work will continue for growth/evolution versions and supporting infrastructure to satisfy launch requirements for future exploration missions.

The SPIP will focus on nozzles, bondlines, verification testing, and on infusing technology engineering results and cultural changes into flight programs. This program was previously funded as part of the Upper Stages line item. Starting in FY 1993, it will be transferred to Advanced programs in consideration of the developmental nature of its .activities.

BASIS FOR FY 1993 FUNDING REQUIREMENT

NEW LAUNCH SYSTEM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
New launch system (NLS)	23,900	175,000	38,000	125,000

OBJECTIVES AND STATUS

The purpose of this joint NASA/DOD program is to develop a new evolutionary unmanned (but man-rateable) launch system to support both civil and defense applications. Developing such a new launch system to provide the U.S. with a flexible heavy lift capacity was a key recommendation of the Advisory Committee on the Future of the U.S. Space Program. Preliminary plans for the New Launch System (NLS) have been reviewed and approved by the National Space Council. The objective of this program, as set forth in the July 1991 National Space Launch Strategy approved by the President, is to greatly improve national launch capability by reducing operating costs and improving launch system reliability, responsiveness, and mission performance. In addition to taking operational pressure off the Shuttle and other existing launch vehicles for cargo missions, NLS offers capabilities for launching a variety of spacecraft. If combined with a manned spacecraft, some variation of the new system could eventually complement the Shuttle to provide assured manned access to space. In the longer term, the NLS may be evolved to provide the lift capabilities required to support space exploration missions as well as providing possible operational support to Space Station Freedom (SSF). The NLS program will be jointly managed by NASA and DOD, with an equal share in common program goals.

The NLS-1 (125,000-135,000 lbs to Low Earth Orbit (LEO) and 90,000-100,000 lbs to SSF orbit) and NLS-2 (capable of placing 50,000 lbs into LEO) will be derived from a common core element consisting of the Shuttle external tank and a new Space Transportation Main Engine (STME). The NLS-3 (capable of placing 20,000 lbs into LEO) will have a smaller diameter tank but will use a single STME; it is intended for use by the DOD and is to be launched from Cape Canaveral Air Force Station (CCAFS). The NLS-2 will be utilized by both NASA and DOD and can be launched from either the Kennedy Space Center or CCAFS. The NLS-1 will be launched exclusively from KSC. The core vehicle also has the potential of serving as the central element of large payload capability vehicles (300,000 to 550,000 lbs) responding to future space exploration and Defense requirements.

Substantial progress has been made in defining the NLS since early 1991 when the National Space Council directed NASA and DOD to define a plan to jointly develop and fund this new space launch system. Major emphasis has been placed on the preliminary design and development of the STME with a team of three major engine contractors. A comprehensive government/industry team is in place for overall vehicle system design and definition of the supporting infrastructure. Efforts are underway to refine program management and systems acquisition strategies. Excellent progress has also been made in the supporting advanced development efforts including avionics, a breadboard engine controller, and test firing a 40,000 lb thrust subscale injector.

NASA and DOD are also currently preparing a program management plan, a program acquisition plan, and preliminary payload transition plans. In response to concerns raised by several Congressional committees regarding long term program costs, activities are also underway to refine program cost estimates and assess options for modifying the program to reduce future funding requirements for both development and operations.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The current budget reflects a reduction of $137.0 million. This budget reduction brings the total funding (NASA and DOD) anticipated for 1992 from $350.0 million to under $100.0 million. This reduced level supports a 2002 first launch schedule. Consistent with Congressional direction, $28.0 million of NASA funds will support STME development activities. Total NASA/DOD funding for STME will be approximately $60.0 million. The remaining $10 million of NASA funds will support vehicle studies and systems engineering.

BASIS FOR FY 1993 ESTIMATE

With the FY 1993 NASA funding and an equal amount from the DOD, the preliminary design effort for the NLS will be completed and the program will be ready for an FY 1993 vehicle program start decision leading to a first launch in 2002.

The NASA activity at MSFC will be completing preliminary design of the common core, and completing the definition of the structure, propulsion system, avionics, and vehicle interfaces. Cargo Transfer Vehicle (CTV) activities will focus on design and interface definition. The STME activities will be directed toward completion of the engine design, continued testing of key components, continuation of work on the Component Test Facility (CTF) at the Stennis Space Center, and the initiation of test stand modifications for a first engine hot-firing in 1997. NASA activity at KSC will complete operations planning support.

The NLS Joint Program Office (JPO) will complete the system baseline design. It will identify the baseline design of all major systems, the interface requirements between the NLS flight and ground elements, and payload accommodations. The definition of NLS-3 utilizing the STME and common core avionics, and the upper stage will be completed.

BASIS FOR FY 1993 FUNDING REQUIREMENT

TETHERED SATELLITE SYSTEM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Tethered satellite system (TSS)	21,900	12,600	16,400	3,400

OBJECTIVES AND STATUS

The development of a Tethered Satellite System (TSS) will provide a new reusable space facility for conducting space experiments at distances up to 100 kilometers from the Shuttle orbiter while being held in a fixed position relative to the orbiter. A number of significant and unique scientific and engineering objectives can be undertaken with a TSS facility such as the observation of important atmospheric processes occurring within the lower thermosphere, improve observations of crustal geomagnetic phenomena, and entirely new electrodynamic experiments interacting with the space plasma. This effort is underway as a cooperative development program with the Italian government.

The United States is responsible for overall program management, overall systems engineering and integration, orbiter integration, ground and flight operations, development of the deployment mechanism and provision of the non-European instruments (Office of Space Science and Applications (OSSA) funded). The Italians are responsible for the design and development of the satellite and the European instruments being flown on the joint missions. The cooperative efforts were initiated in 1984.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The $3.8 million increase is due to the slip in launch from February 1992 to August 1992 as a result of recent manifest changes.

BASIS OF FY 1993 ESTIMATE

The FY 1992 and FY 1993 funding is consistent with a mission in August 1992 and supports post-mission activities. Emphasis is being placed on the dynamics of the TSS, especially in the area of possible off-nominal conditions, safety requirements, and post-mission analysis.

BASIS OF FY 1993 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Research operations support	(169,047)	(190,844)	144,600	177,200

OBJECTIVES AND STATUS

Research and operations support funding provides vital support to the civil service workforce and to the physical plant at the centers and at NASA headquarters. Support to the civil service workforce includes provision of the basic tools to work productively, such as telephone and mail service, office supplies, equipment and furniture, and the basic photo, printing and graphics shops. Support to the physical plant includes payment for center utilities, rental of buildings and space, and necessary fire protection, janitorial, and security services. Support to the physical plant also includes maintenance of roads, grounds and general purpose facilities such as administrative buildings and the extensive utilities systems.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Until FY 1992 these activities were funded in the Research and Program Management (R&PM)/Operation of Installation appropriation. FY 1992 Congressional action both sharply reduced the requested funding for these activities, shown in parenthesis, and authorized their transfer into the Research and Development (R&D) and Space Flight Control and Data Communications (SFCDC) appropriations. This transfer has allowed the reduction to be accommodated with minimum impact by allowing the programs to fund some of the activities that had previously been covered by these funds.

BASIS OF FY 1993 ESTIMATE

NASA is in the process of deciding exactly how the activities previously budgeted in the Operation of Installation account will be budgeted in future years. The FY 1993 estimate represents the amount required to provide the basic minimum institutional support. It will be necessary to develop mechanisms that either allow this estimate to be supplemented by program funds or that incorporates some of the funding for these activities in the program budgets.

SPACE SCIENCE
AND APPLICATIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1993 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE AND APPLICATIONS

	Budget Plan				
		1992		1993	
	1991 Actual	Budget Estimate	Current Estimate	Budget Estimate	Page Number
	(Thousands of Dollars)				
Physics and astronomy	969,167	1,140,600	1,047,300	1,113,500	RD 3-1
Life sciences	137,400	183,900	145,800	177,200	RD 4-1
Planetary exploration	473,700	627,300	535,600	487,200	RD 5-1
Earth science	662,300	775,600	738,500	868,500	RD 6-1
Materials processing in space	102,300	125,800	118,800	195,300	RD 7-1
Communications	50,500	39,400	12,500	4,600	RD 8-1
Information systems	35,700	42,000	35,000	40,700	RD 9-1
Research operations support	(92,355)	(112,173)	82,300	98,000	RD 9-4
Total	2,431,067	2,934,600	2,715,800	2,985,000	

PHYSICS AND
ASTRONOMY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Gamma ray observatory development	22,000	--	--	--	RD 3-6
Global geospace science	96,600	65,300	75,300	60,100	RD 3-7
Advanced x-ray astrophysics facility development (AXAF)	101,200	211,000	151,000	174,000	RD 3-9
Payload and instrument development	92,600	115,900	116,500	78,200	RD 3-11
Shuttle/Spacelab payload mission management and integration	88,800	88,000	88,000	101,100	RD 3-13
Space station integration planning	3,000	--	--	--	RD 3-15
Explorer development	99,800	107,900	105,000	112,500	RD 3-16
Mission operations and data analysis ..	311,900	388,400	380,800	440,900	RD 3-18
Research and analysis	98,267	103,100	70,500	81,400	RD 3-20
Suborbital program...................	55.000	61.000	60.200	65.300	RD 3-22
Total	969.162	1,140,600	1.047.300	1.113.500	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Johnson Space Center	16,919	17,200	14,728	16,927
Kennedy Space Center	13,312	10,300	14,763	17,659
Marshall Space Flight Center	226,675	301,600	258,804	261,577
Goddard Space Flight Center	619,041	686,900	636,529	668,680
Jet Propulsion Laboratory	27,462	30,800	37,629	51,558
Ames Research Center	13,290	9,100	13,848	24,413
Lewis Research Center	--	500	--	--
Headquarters	52.468	84.200	70,999	72.686
Total	969.167	1.140.600	1,047,300	1.113.500

OBJECTIVES AND JUSTIFICATION

The objectives of the Physics and Astronomy program are to increase our understanding of the origin and evolution of the universe, the fundamental laws of physics, and the formation of stars and planets. Objects studied by the astrophysics program include distant galaxies and galactic clusters, as well as stars and other structures in nearby galaxies and the interstellar medium in our galaxy. Unusual and exotic phenomena -- such as quasars, neutron stars, pulsars and black holes -- are of particular interest to the astrophysics program, and are the target of many ground-based and space-based research programs. In the space physics program, intensive study of our own sun, with its multitude of time-varying phenomena, provides key answers to a vast range of questions requiring comprehensive research into solar-terrestrial processes and the physics and coupling between the solar wind, magnetosphere, ionosphere, and atmosphere.

The objectives of the Physics and Astronomy program are accomplished with a mixture of large free-flying space missions, smaller Explorer spacecraft, Shuttle/Spacelab flights and suborbital missions. Space-based research allows observations in the infrared and the ultraviolet wavelengths which cannot be conducted on the ground due to the obscuring effects of the atmosphere. Also, observations in the visible light region are vastly improved when conducted above the atmosphere. The entire program rests on a solid basis of supporting research and technology, data analysis, and theory.

Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories. The scientific information obtained and the technology developed in this program are made available to the scientific communities and the general public for application to the advancement of scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful. Recently, these include the Cosmic Background Explorer (COBE, 1989), the Roentgen Satellite (ROSAT, 1990), the Combined Release and Radiation Effects Satellite (CRRES, 1990), the Hubble Space Telescope (HST, 1990), the Astro-1 mission (1990), the Gamma Ray Observatory (1991), and the Solar-A/Yoh Koh mission (1991).

The HST provides an international spaceborne astronomical observatory capable of measuring objects appreciably fainter and more distant than those accessible from the ground, since it is above the turbulent and absorbent atmosphere. Currently, the Hubble Space Telescope can resolve spatial features by a factor of ten better than ground-based optical telescopes, for objects as dim as the 24th magnitude. Full capability to observe objects from the 25th to the 28th magnitude, originally planned for Hubble, will be restored by the 1993 servicing mission with the Wide Field/Planetary Camera II and Corrective Space Telescope Axial Replacement instruments. This increased capability will allow us to address basic questions concerning the origin, evolution, and disposition of galaxies, quasars, clusters, and stars, thus allowing us to increase significantly our understanding of both the early and present universe--its beginning and end.

The Gamma Ray Observatory (GRO), renamed the Compton Observatory, was launched by the Space Shuttle in April 1991. This mission measures gamma rays, which are produced by the most energetic and exotic fundamental physical processes occurring in nature. Instruments on this mission provide unique information on phenomena occurring in quasars, active galaxies, black holes, neutron stars, supernova, and the nature of the mysterious cosmic gamma-ray bursts.

The Global Geospace Science (GGS) program is a complementary science mission to the Collaborative Solar-Terrestrial Research (COSTR) project and establishes the U.S. as a leader in solar-terrestrial physics research. These projects, collectively referred to as the International Solar-Terrestrial Physics (ISTP) program, are being conducted in cooperation with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronautical Science (ISAS). The GGS spacecraft will make the first coordinated geospace measurements in the key plasma source and storage regions, with emphasis on the cause-effect relationships of energy flow.

The Advanced X-ray Astrophysics Facility (AXAF) was approved as a FY 1989 new start for the x-ray telescope assembly and high resolution mirror assembly. The start of spacecraft initial design is planned for FY 1992. The AXAF will be a major national observatory for x-ray astronomy. The 1.2 meter-class grazing incidence telescope will provide a factor of 100 increase in sensitivity, a factor of 10 increase in angular resolution and double the energy coverage provided by the Einstein observatory (HEAO-2). It will provide new observations and insights in studies of stellar structure and evolution, large-scale galactic phenomena, active galaxies, clusters of galaxies and cosmology. It will restore U.S. leadership in a field pioneered by U.S. astronomers.

Shuttle/Spacelab and attached payload mission management activities will continue with increasing emphasis on major life sciences and microgravity research missions such as the series of Spacelab-Life Sciences (SLS), International Microgravity Laboratory (IML) and the United States Microgravity Laboratory (USML) missions. Other missions scheduled include the Atmospheric Laboratory for Applications and Science (ATLAS) series, the United States Microgravity Payload (USMP) series, the Space Radar Laboratory (SRL) series, and a variety of other Shuttle and middeck experiments.

A U.S. instrument was developed for flight on the Japanese Solar-A/Yoh Koh mission, which was launched in August 1991, to study the sun during the upcoming solar maximum. Explorer missions currently under development are the Extreme Ultraviolet Explorer (EUVE), the X-Ray Timing Explorer (XTE), and the Solar, Anomalous and Magnetospheric Particle Explorer (SAMPEX). Finally, the Explorer program supports U.S. participation in the Japanese Astro-D Spectroscopic X-ray Observatory Mission, to be launched in 1993.

Payload and instrument development activities provide the data necessary to conduct basic research projects and to provide correlative and development feasibility information for major free-flying spacecraft. Instrument development activities include Shuttle payloads such as the Tethered Satellite System (TSS). Also included are Space Plasma Physics flight of opportunity instruments such as those for the Japanese Geotail spacecraft and the European Solar and Heliospheric Observatory (SOHO) and Cluster spacecraft under the COSTR program.

During the past several years, suborbital observation from balloons, sounding rockets, and high-flying aircraft took on increased significance. This enhanced effort will continue to provide observations and instrument development opportunities for research groups. Furthermore, increased emphasis will also continue in the research and analysis (R&A) and the mission operations and data analysis (MO&DA) areas in order to maintain a vital research base in Physics and Astronomy.

BASIS OF FY 1993 FUNDING REQUIREMENT

GAMMA RAY OBSERVATORY DEVELOPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	19,100	--	--	--
Experiments and ground operations	2.900	--	--	--
Total	22.000	--	--	--

OBJECTIVES AND STATUS

The Gamma Ray Observatory (GRO) is studying the highest energy electromagnetic radiation emitted from sources in the cosmos. This spectral region represents one of the last frontiers in astronomy to be studied at high sensitivity. Because of their extreme energy, gamma-rays are produced by the most energetic and intriguing phenomena occurring in the universe: phenomena occurring in the central energy source region of quasars, in supernovae, near black holes, and on the surface of neutron stars. Gamma-rays provide the unique direct signature of all nuclear processes which occur in astrophysics: the synthesis of elements, cosmic rays interacting in the interstellar medium, and transformations involving the fundamental particles of physics. GRO is providing new information on phenomena ranging from cosmic gamma-ray bursts to the diffuse gamma-ray sky background.

Due to the low flux of cosmic gamma-rays, their penetrating nature, and the high background produced by cosmic-ray interactions, detailed observations require large instruments to be flown in space for extended periods of time. The four complementary instruments selected for the GRO represent a major increase in sensitivity, spectral range, and spectral, spatial, and temporal resolution in these energy ranges over instruments flown on any previous missions.

BASIS O NG RE UIREMENT

GLOBAL GEOSPACE SCIENCE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Global geospace science	96,600	65,300	75,300	60,100
Mission operations and data analysis	--	(1,500)	(2,500)	(16,000)
Launch vehicles	(52,900)	(36,400)	(30,400)	(15,600)

OBJECTIVES AND STA

Global Geospace Science (GGS) will be part of the United States' contribution to the International Solar Terrestrial Physics (ISTP) program. This program is an international, multi-spacecraft, collaborative science mission designed to provide the measurements necessary for a new and comprehensive understanding of the interaction between the sun and the Earth. GGS will allow the United States to become a full partner in the ISTP program, reinforcing our commitments to international cooperation and maintaining a leadership role in solar-terrestrial physics.

GGS is a complementary science mission to the Collaborative Solar Terrestrial Research (COSTR) program which provides instruments and launch support to gain science return in a cooperative effort with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronautical Science (ISAS). The scientific value of this effort will be greatly enhanced by the addition of the two GGS spacecraft. The combined ISTP program will include eight spacecraft: two U.S. spacecraft, Wind and Polar; five ESA spacecraft, including the Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft; and one ISAS spacecraft, Geotail.

The GGS mission will measure and model the effects of the sun on the Earth's space system to enhance our understanding of the processes and flow of energy and matter in the solar energy chain from outer geospace to atmospheric deposition. GGS will also enhance our ability to assess the importance of variations in atmospheric energy deposition from the geospace system to the terrestrial environment. GGS consists of two fully-instrumented U.S. spacecraft, Wind and Polar, making simultaneous measurements in key geospace regions. GGS will provide the first coordinated geospace measurements in key plasma source and storage regions, multi-spectral global auroral imaging, and multi-point study of magnetospheric response to solar wind.

Spacecraft contract award was completed in FY 1989, as was final confirmation and initiation of instrument development activity. The instruments are completing fabrication and test activities and are scheduled for delivery in FY 1992. Due to a number of problems, most notably delays in spacecraft manufacturing, both spacecraft launches will be delayed several months. Wind, previously planned for a late 1992 launch is now scheduled for launch in mid/late 1993. The Polar launch is delayed from mid-1993 to mid-1994.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The GGS FY 1992 budget has been increased by $10.0 million due to manufacturing delays and related problems with the spacecraft development contractor in an effort to maintain the earliest possible launch dates for both missions.

BASIS OF FY 1993 ESTIMATE

FY 1993 funds are required to continue development of the Wind and Polar spacecraft, instruments and ground system. Funding will allow continuation of these development efforts in order to take advantage of simultaneous measurements provided by the COSTR program and other solar-terrestrial research efforts. FY 1993 funds will allow for completion of Wind integration and environmental testing for a planned launch in 1993. Completion of Polar spacecraft and instrument integration and testing will be conducted in preparation for a mid-1994 launch.

NG REQU MENT

ADVANCED X-RAY SICS FACILITY OPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	**91,600**	**188,700**	**141,300**	**148,000**
Experiments	**9,600**	**22,300**	**9,700**	**26,000**
Total	101,200	211,000	**151,000**	174,000
Mission operations and data analysis..	**(2,800)**	(7,800)	(3,300)	**(14,900)**
AXAF advanced technology development..	**(20,700)**			
Integrated propulsion system				**(8,000)**

OBJECTIVES AND STATUS

The Advanced X-ray Astrophysics Facility (AXAF) is the next major advance in x-ray astronomy and is the third of the "Great Observatories." The AXAF will provide new observations and insights into studies of stellar structures and evolution, large-scale galactic phenomena, active galaxies, clusters of galaxies, and cosmology. The 1.2 meter grazing incidence telescope will provide a factor of 100 increase in sensitivity, a factor of ten increase in angular resolution, double the energy coverage which was provided by the Einstein Observatory **(HEAO-2)**, and will address fundamental questions of modern astrophysics. Timely development of the AXAF program is required in order to fly in concert with the Hubble Space Telescope, now observing the universe in visible and ultraviolet radiation, and the Gamma Ray Observatory, which will conduct observations in the gamma ray spectrum. The scientific return of these Great Observatories will be enhanced enormously if flown together to observe the whole range of phenomena in the cosmos, from the most tranquil to the most violent, and provide a complete physical picture of the most enigmatic objects in the universe.

The AXAF will be a long-lived observatory designed for on-orbit instrument replacement and servicing. With the Shuttle, the U.S. will have the unique capability to maintain this telescope in orbit.

In FY **1990,** AXAF development activities commenced on the High Resolution Mirror Assembly/X-ray Telescope Assembly (HRMA/XTA), with a particular focus on development of the flight mirrors at Hughes-Danbury Optical Systems (HDOS) in Danbury, Connecticut. In accordance with Congressional agreement, AXAF instrument and observatory definition activities were funded under research and analysis.

In FY 1991, development was completed on the largest and most challenging set of parabolic/hyperbolic mirrors (P-1/H-1). This set of mirrors was tested at the x-ray calibration facility at the Marshall Space Flight Center (MSFC) in September 1991, and met all Congressionally mandated milestones.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Congressional action reduced development funding by $60.0 million in FY 1992. Work on the spacecraft, the instruments, and the mirror assembly has been deferred consistent with this reduction with the launch date delayed from early 1998 to mid-1999.

BASIS OF FY 1993 ESTIMATE

With the FY 1992 budget reduction and subsequent launch delay, the program is being rebaselined consistent with the 1999 launch. A major effort in FY 1993 will be concentrated on fabricating, grinding and polishing the remaining five mirror pairs at Hughes-Danbury Optical Systems (HDOS) in an effort to complete this major technical challenge and complete delivery in 1994 and 1995. Lessons learned from the P1/H1 fabrication effort will be incorporated into improvements and upgrades to grinding and polishing machinery and software in an effort to improve accuracy, reliability, safety and data cross-checks. The preliminary design audit of the High Resolution Mirror Assembly (HRMA) will occur in mid-1993.

Spacecraft development activities will increase significantly at the mission contractor (TRW), with continued design effort culminating in a Preliminary Design Review (PDR) in 1994. Selected instruments to be flown on AXAF -- the AXAF CCD Imaging Spectrometer (ACIS), High Resolution Camera (HRC), High Energy Transmission Grating (HETG), X-Ray Spectrometer (XRS) and the Bragg Crystal Spectrometer (BCS) -- will continue design activities leading to instrument PDRs in late 1993 and 1994.

With the deletion of the Advanced Solid Rocket Motor (ASRM) capability, use of the current Shuttle solid rocket boosters would deploy AXAF into a 218 nautical mile (nm) parking orbit, with a projected lifetime of less than one year. To transfer to the optimum 320 nm operational altitude, an Integrated Propulsion System (IPS) is required. The IPS will reduce the AXAF requirement for periodic reboost by the Shuttle, allowing its servicing needs to be met by fewer Shuttle flights during its operational lifetime. The budget requirement for this propulsion system is carried in the FY 1993 budget under Expendable Launch Vehicles/Upper Stages.

BASIS OF FY 1993 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Collaborative solar terrestrial research	58,200	64,700	62,500	50,300
Tether satellite systems	4,000	1,600	1,600	3,300
Shuttle test of relativity experiment	23,400	29,400	27,200	--
Astrophysics payloads	3,800	18,700	23,700	23,700
Space physics payloads	3,200	1,500	1,500	900
Total	92,600	115,900	116,500	78,200

OBJECTIVES AND STATUS

Instrument development activities support a wide range of instrument tion - from early test. ch ckout and design of instruments for long-duration free-flying missions to international flights of opportunity.

The Collaborative Solar Terrestrial Research (COSTR) program, in conjunction with the Global Geospace Science program, represents the U.S. contribution to the International Solar Terrestrial Program (ISTP). While GGS provides U.S. spacecraft and instruments, COSTR provides U.S. instruments for flights of opportunity aboard foreign spacecraft. These include the Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft provided by the European Space Agency (ESA), and the Geotail mission developed by Japan. Geotail is scheduled for a mid-1992 launch, and the European SOHO and Cluster missions will launch in 1995. COSTR complements the science return from GGS by providing measurements of the flow of solar energy and matter from different points in the solar system. This will provide a more comprehensive understanding of the Sun-Earth space system.

The Tethered Satellite System (TSS), scheduled for launch in mid-1992, will provide a facility for conducting experiments weighing 500 kg or less from distances of 100 km above or below the Space Shuttle. The objective of the TSS mission (TSS-1) is to verify the controlled deployment, retrieval and on-station stabilization of a satellite tethered from the orbiter, and to carry out an electrodynamics experiment using a conducting tether extended 20 km above the orbiter. The TSS-1 is an international cooperative project with the Italian government. The U.S. is responsible for overall project management, system integration, development the tether deployment and retrieval system, development and integration of the U.S.-provided instruments, and flight on the Space Shuttle. Italy is developing the satellite and is responsible for development and integration of Italian-provided instruments.

Astrophysics and space physics payloads include a number of instruments designed for flight on the Space Shuttle and ELVs. Emphasis will be on instrument development for the study of the complex relationships of solar irradiance and the near-Earth plasma environment (Atmospheric Laboratory for Applications and Science - ATLAS missions) as well as for the study of the ultraviolet and x-ray universe.

As an integral part of the study of relativity, the Shuttle Test of Relativity Experiment (STORE) flight of the Gravity Probe-B instrument involves the development of a multigyroscope experimentation package to fly as an attached payload on a Shuttle flight planned for 1994.

CHANGES FROM 1992 BUDGET ESTIMATE

The COSTR program has been reduced by $2.2 million to fund increased requirements in the related Global Geospace Science (GGS) program. In accordance with Congressional direction, $5.0 million has been included to support reflight of the Astro-1 ultraviolet instruments in the Astro-2 mission. In accordance with Congressional direction, the Shuttle Test of Relativity Experiment (STORE) has been reduced by $2.2 million. Due to budget constraints, a decision has been made to terminate the program beginning in FY 1993. FY 1992 funds will therefore be required to complete selected fabrication and test activities and to terminate the program.

BASIS OF FY 1993 ESTIMATE

In FY 1993, the COSTR program will continue the development of instruments and mission support equipment for the ESA/NASA Cluster and SOHO missions. Funding is also required to support instruments and core equipment development and integration on TSS-1. Funding will support data analysis from the Astro mission as well as development of instruments and data analysis activities post-launch for the ATLAS and Diffuse X-ray Spectrometer (DXS) spacelab missions, which will launch in 1992. Funding will also be applied to the U.S.-provided instruments on the international/cooperative efforts consistent with current agreements. As stated above, all activities for the STORE program have been terminated.

BASIS OF FY 1993 FUNDING REOUIREMENT

SHUTTLE/SPACELAB PAYLOAD MISSION MANAGEMENT AND INTEGRATION

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Shuttle/Spacelab payload mission management and integration	88,800	88,000	88,000	101,100

OBJECTIVES AND STATUS

The primary objective of the Spacelab payload mission management program is to manage the mission planning, integration, and execution of all NASA Spacelab and attached Shuttle payloads. This includes system management and engineering development of flight support equipment and software; development of certain interface hardware; payload specialist training and support; integration of the science payloads with the Spacelab system; payload flight operations; and data dissemination to experimenters.

Mission management activities for Physics and Astronomy missions include the upcoming Diffuse X-ray Spectrometer (DXS) mission which is currently planned for flight in December 1992. Mission management activities are ongoing for several other space science and applications missions such as the Atmospheric Laboratory for Applications and Science (ATLAS). The first of this series is planned for flight in March 1992. The mission will incorporate a large number of instruments designed to study the complex relationships of solar irradiance, atmospheric composition and changes, and the near-Earth plasma environment. Other missions include several flights of the Space Radar Laboratory (SRL) beginning in late 1993; a series of Spacelab Life Sciences (SLS) missions (SLS-1 was launched in mid-1991); a joint microgravity mission with the Japanese (SL-J) in August 1992; a series of cooperative International Microgravity Laboratories (IMLs); a series of U.S. Microgravity Payloads (USMPs) and U.S. Microgravity Laboratories (USMLs), each of which have their first flight in 1992; and flight of the Canadian Waves in Space Plasma (WISP) instrument in 1995. Mission management activities also support other NASA payloads, for example, the Lidar In-space Technology Experiment (LITE; a 1994 launch) which will demonstrate technology and measurement techniques with high potential for use in studies of the Earth's atmosphere. Several Shuttle middeck experiments are also supported.

BASIS OF FY 1993 ESTIMATE

Mission management activities will continue in FY 1993 as Spacelab missions continue to launch every few months. Integration, testing, and evaluation will continue for major Shuttle/Spacelab missions including the Diffuse X-ray Spectrometer (DXS), Spacelab Life Science series (SLS-2), the ATLAS series (ATLAS-2), and the first flight of the SRL series (SRL-1). Preparation for FY 1994 missions will proceed, including flights of the ongoing series of Atmospheric Laboratory for Applications and Science (ATLAS-3), the International Microgravity Laboratory (IML-2), the Lidar In-space Technology Experiment (LITE), and the United States Microgravity Payloads (USMP-2).

BASIS OF FY 1993 FUNDING REQUIREMENT

SPACE STATION INTEGRATION PLANNING AND ATTACHED PAYLOADS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Space station integration planning	3,000	--	--	--

OBJECTIVES AND STATUS

The primary aim of the Space Station integration planning and attached payload definition program is to perform the necessary planning and definition of payloads for the space science and applications use of Space Station Freedom (SSF). This includes the initial definition of the attached payloads selected in FY 1989 through a competitive Announcement of Opportunity for early deployment on the Space Station. The program also involves definition of integration and operations requirements to guide the planned development of Space Station and science support capabilities.

In FY 1991, studies continued to define the end-to-end science operations requirement for the Space Station era (i.e., the cycle from identification of an experiment, through operations to dissemination, analysis and archiving of data). Studies also continued to determine the best use of Space Station resources (such as power, crew time, volume, data handling capabilities) for science requirements. Functions associated with Space Station integration planning have been transferred to Materials Processing beginning in FY 1992. The Space Station Freedom program will assume the responsibilities associated with science utilization management.

BASIS OF FY 1993 FUNDING REQUIREMENT

EXPLORER DEVELOPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Extreme ultraviolet explorer	10,300	4,400	4,400	--
Explorer platfo.......................	24,942	6,900	7,200	--
X-ray timing explorer	15,700	37,400	49,400	65,100
Small explorers	27,900	34,800	33,600	35,000
Other explorers	20.958	24.400	10.400	12.400
Total............................	99.800	107.900	105.000	112.500
ELV	(6,400)	(17,400)	(10,000)	(4,700)

OBJECTIVES AND STATUS

Investigations selected for these projects are usually of an exploratory or survey nature, or have specific objectives not requiring the capabilities of a major observatory. Past Explorers have discovered radiation trapped within the Earth's magnetic field, investigated the solar wind and its interaction with the Earth, studied upper atmosphere dynamics and chemistry, mapped our galaxy in radio waves and gamma-rays, and determined properties of the interstellar medium through ultraviolet observations. Recent Explorers have performed active plasma experiments on the magnetosphere, made in situ measurements of the comet Giacobini-Zinner, and completed the first high sensitivity, all-sky survey in the infrared, discovering over 300,000 sources.

The Cosmic Background Explorer (COBE) was launched in November 1989, and is currently studying the properties of the cosmic microwave background. This is important for understanding the early universe and cosmology. In FY 1990, COBE completed a successful, all-sky survey of the infrared and microwave background radiation of the universe between the wavelengths of one micrometer and 9.6 millimeters. Current Explorers under development will survey the sky in the extreme ultraviolet for the first time and measure time variable phenomena in x-ray sources.

In FY 1992, development continues on the Extreme Ultraviolet Explorer (EWE). The EWE, scheduled for launch on a Delta launch vehicle in 1992, will carry out the first all-sky survey in the extreme ultraviolet spectrum; the first deep survey of a section of the ecliptic plane in the extreme ultraviolet; and systematic spectroscopy of sources discovered in the all-sky survey to identify the emission physics.

In addition to the traditional Delta-class explorers, a Small Explorer (SMFX) program was initiated in FY 1989. While subject to more stringent constraints than Delta-class missions (weight, telemetry, power, etc.), it is anticipated that a significant number of scientifically exciting missions can utilize this capability and be developed on a short timescale. Fifty-one proposals were received in response to the Small Explorer Announcement of Opportunity (AO). Following peer review, three payloads were selected for development in Spring 1989. The first of these three missions, the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX), is scheduled for launch on a Scout launch vehicle in 1992. The two subsequent missions, the Fast Auroral Snapshot Explorer (FAST) and the Submillimeter Wave Astronomy Satellite (SWAS), are to be launched in 1994 and 1995 respectively.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The Explorer budget was reduced a net of $2.9 million. The XTE mission was increased by $12.0 million to accommodate a transition from the previously-planned changeout with EWE on the Explorer Platform. Current plans are to fly the XTE science payload aboard a dedicated spacecraft with an ELV launch in 1996. Increased funds will allow initial spacecraft development activities. This increase as well as the general reduction, was largely offset by deferring advanced planning activities in the "Other Explorers" line.

BASIS OF FY 1993 ESTIMATE

Development activities on the XTE mission will continue in preparation for a Delta launch in 1996. The SMEX program will be well underway as the first mission, SAMPEX, launches in mid-1992. The other SMEX missions currently underway, FAST and SWAS, will continue development in preparation for launches in 1994 and 1995, respectively. Two new delta-class explorers, the Advanced Composition Explorer (ACE) and the Far Ultraviolet Spectroscopic Explorer (FUSE) have been selected for future development. Phase B activities for these missions are now being conducted and will continue through FY 1993.

BASIS OF FY 1993 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Hubble space telescope operations and servicing	186,000	209,200	209,200	214,200
Hubble space telescope data analysis ..	35,900	36,000	36,000	42,300
Astrophysics mission operations and data analysis	68,500	98,300	92,700	115,400
Space physics mission operations and data analysis	21,500	44,900	42,900	69,000
Total	311,900	388,400	380,800	440,900

BJECTIVES AND STATUS

The purpose of the mission operations and data analysis effort is to conduct operations and analyze data received from physics and astronomy spacecraft. The program also supports the operation of a number of spacecraft after their originally planned objectives have been achieved, for purposes of conducting specific investigations that have continuing high scientific significance. The funding supports the data analysis activities of many investigators at universities and other research organizations associated with astrophysics and space physics operational satellite projects as well as theoretical work based on space observations. Actual satellite operations, including control centers and related data reduction and engineering support activities, are typically conducted under a variety of mission support or center support contracts.

Space Physics research activities rely on data received from the following operational spacecraft: the International Monitoring Platform (IMP), which provides the only available source of solar wind input measurements to the Earth; the Japanese Solar-A/Yoh Koh spacecraft, launched in 1991; and the Voyager and Ulysses spacecraft, for which management responsibility was assumed from the Solar System Exploration Division in FY 1992. In addition, the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) and the Japanese Geotail spacecraft are scheduled for launch in 1992. Data analysis activities are also continuing for the highly successful Solar Maximum Mission (SMM); the Combined Release and Radiation Effects Satellite (CRRES); the International Cometary Explorer (ICE); the Dynamics Explorer (DE); and the Active Magnetospheric Particle Trace Explorer (AMPTE).

The Hubble Space Telescope (HST) is designed to operate for fifteen years, requiring on-orbit maintenance of the spacecraft and on-orbit changeout of the scientific instruments. The first planned servicing mission, scheduled for 1993, will put into place optical corrections to accommodate the spherical aberration of the primary mirror. The capabilities lost due to spherical aberration--narrow field spectroscopy and observation of 25th to 28th magnitude objects--will be restored. The HST is used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. Science operations are carried out through an independent HST Science Institute. The Institute operates under a long-term contract with NASA. While NASA retains operational responsibility for the observatory, the Institute implements NASA policies in the area of planning, management, and scheduling of the scientific operations of the HST.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Space Physics MOWA has been reduced by $2.0 million to partially offset the increase in Global Geospace Science (GGS) Development. An additional $5.6 million reduction was taken in Astrophysics MOWA as part of the Congressional general reduction. This will defer planned AXAF operations and servicing activities commensurate with the aforementioned launch delay.

BASIS OF FY 1993 ESTIMATE

The FY 1993 funding level is required to support mission operations and data analysis for ongoing missions including COBE, HST, GRO, ROSAT, and EWE. Servicing mission activities on HST will continue, including development and test of optical corrections for replacement instruments, and preparations for the first planned servicing mission in 1993. Second-generation HST instruments will continue development for future on-orbit replacement, as will a continuing line of spare subsystems to ensure operational efficiency throughout its planned 15-year lifetime.

FY 1993 funding for Space Physics mission operations and data analysis will support the following operational spacecraft: IMP, Yoh Koh, SAMPEX, Voyager, Ulysses, Geotail, WIND, and Pioneer. Data analysis on the AMPTE and DE data sets will continue; however, data analysis activities for SMM and CRRES will cease as these spacecraft have completed their basic mission objectives and the spacecraft are no longer operating.

BASIS OF FY 1993 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology	77,600	103,100	70,500	81,400
Advanced technology development	20.667	--	--	--
Total	98.267	103.100	70.500	81.400

OBJECTIVES AND STATUS

This program provides for the preliminary studies required to define missions and/or payload requirements as well as providing a research and technology base necessary to define, plan and support flight projects.

The objectives of supporting research and technology (SR&T) are to: (1) optimize the return expected from future missions through scientific problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; (2) enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; (3) develop theories to explain observed phenomena and predict new ones; (4) strengthen the technological base for sensor and instrumentation development and conduct the basic research necessary to understand astrophysics phenomena and solar-terrestrial relationships; and, (5) continue the acquisition, analysis and evaluation of data from laboratories, balloons, rocket and spacecraft activities.

Research is supported in the disciplines of astronomy, astrophysics, gravitational physics, plasma, cosmic ray and solar physics. Research in astronomy and astrophysics involves the study of stars, galaxies, interstellar and intergalactic matter, and cosmic rays. Space physics research and analysis is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in the solar corona, the interplanetary medium and in the vicinity of the Earth and other planets. Theory activities are related to all the physics and astronomy disciplines and are critical to the correlation of available information. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments will also be continued. Results achieved in the SR&T program will have a direct bearing on future flight programs. For example, the development of advanced x-ray, ultraviolet, and infrared astronomy imaging devices under this program may enable spacecraft to carry instruments for astronomical observations which have increased orders of magnitude in sensitivity and improved resolution over currently available detectors.

One major thrust of the space physics program is directed at studies of the near-Earth geospace environment, from the flow of the solar wind past the magnetosphere, to variations of the plasma environment detectable near the surface of the Earth. Not only are these studies of great interest for basic plasma physics but there are also many practical ramifications such as ionospheric influences on communication, global circulation of the atmosphere driven by magnetospheric input, the charging of spacecraft immersed in plasma, and the behavior of antennas and their signals in the magnetosphere.

The SR&T program carries out its objectives through universities, nonprofit and industrial research institutions, NASA centers and other government agencies, Current emphasis is being placed on studies of advanced instrumentation with increased sensitivity and resolution.

FY 1992 activities will continue definition studies of the Stratospheric Observatory for Infrared Astronomy (SOFIA); the Thermosphere, Ionosphere, Mesosphere Energetic and Dynamics (TIMED) mission; and the High Energy Solar Physics (HESP) mission. Studies of the Orbiting Solar Laboratory (OSL) and the Space Infrared Telescope Facility (SIRTF) have been deferred.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Research and analysis funding has been reduced by $32.6 million consistent with Congressional direction. This reflects the deletion of definition studies for the Space Infrared Telescope Facility (SIRTF), the Orbiting Solar Laboratory (OSL), and the Space Exploration Initiative (SEI). These reductions have precluded the initiation of new activities and will constrain all ongoing research at approximately the FY 1991 level.

BASIS OF FY 1993 ESTIMATE

During FY 1993, the supporting research and technology program will continue to support the aforementioned activities in the various science disciplines within astrophysics and space physics which contribute toward maintaining a viable research program. FY 1993 funding will also support continued studies on potential future missions, including TIMED, HESP and SOFIA,

BASIS OF FY 1993 FUNDING REQUIREMENT

SUBORBITAL PROGRAM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Sounding rockets	31,300	34,300	34,300	37,300
Airborne science and applications	11,500	12,000	12,000	12,600
Balloon program......................	12.200	14.700	13.900	15.400
Total	55.000	61.000	60.200	65.300

OBJECTIVES AND STATUS

The suborbital program uses balloons, aircraft, and sounding rockets to conduct versatile, relatively low-cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a national and international cooperative basis.

A major objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars and other celestial objects. Additionally, the sounding rocket program provides several Space Science and Applications programs with the means for flight testing instruments and experiments being developed for future flight missions. The program also provides a means for calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft. Approximately forty rockets are scheduled for launch in FY 1993.

Support for Spartan missions aboard the Shuttle is also included--Spartan 201 and WISP. Spartan 201 consists of a 17-inch diameter solar telescope with an ultraviolet coronagraph and a white light coronagraph to measure the intensity and scattering properties of solar light. Spartan 201 is planned for Shuttle launch in 1993. Spartan has also been selected as the carrier for the Canadian WISP experiment, following cancellation of the Orbital Maneuvering Vehicle program. The WISP/Spartan is planned for launch in 1995.

Research with instrumented jet aircraft has been an integral part of the NASA physics and astronomy program since 1965. For astronomy research, the airborne science and applications program operates the Kuiper Airborne Observatory (KAO). This full-scale manned facility consists of a C-141 aircraft equipped with a 91-centimeter infrared telescope. The C-141's ability to fly for several hours at altitudes approaching 13 kilometers, provides a cloud-free site for astronomical observations above most of the infrared-absorbing water vapor in the Earth's atmosphere. This has been essential in expanding astronomical observations into the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers.

In FY 1991, the C-141 conducted one major campaign in the Southern Hemisphere (seven weeks) to continue studies of the Supernova SN1987A and observations of the galactic center. The KAO is currently the only facility in the world that can conduct these observations in the far infrared and submillimeter wavelengths. The KAO also conducted one deployment to Hawaii. Planetary observations in the infrared (Mars, Pluto, Jupiter) also continue to provide important scientific return.

The Balloon program provides a cost-effective means to test flight instrumentation in the space radiation environment and to make observations at altitudes which are above most of the water vapor in the atmosphere. Balloon experimentation is particularly useful when studying infrared, gamma-ray, and cosmic-ray astronomy. In many instances, it is necessary, because of size, weight, cost, or lack of other opportunities, to fly primary scientific experiments on balloons. In addition to the level-of-effort science observations program, significant emphasis has been and will be placed on development of a balloon capable of lifting more than 3,500 pounds, and to support missions lasting several days.

The Balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery as well as for maintenance and operations of the National Scientific Balloon Facility (NSBF) at Palestine, Texas, and remote launch sites. Funding for the experiments flown on balloons is provided from other research and technology programs supporting the various scientific disciplines.

CHANGES FROM FY 1992 ESTIMATE

Balloon program funding has been reduced by $.8 million in order to partially offset increases in the Global Geospace Science (GGS) program.

BASIS OF FY 1993 ESTIMATE

FY 1993 funds will provide for continuation of the sounding rocket, Spartan, and balloon programs including management and operation of the NSBF. This funding is also required to continue definition and development activities for balloon improvement and long-duration balloon flights. In FY 1993, the Airborne Science and Applications funding will be used to continue flights of the KAO.

LIFE SCIENCES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

LIFE SCIENCES

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
	(Thousands of Dollars)				
Human space flight and systems engineering	58,300	58,600	70,100	71,400	RD 4-4
Space biological sciences	22,800	31,100	14,600	18,300	RD 4-4
Centrifuge	(5,100)	(8,200)	(8,200)	18,400	RD 4-4
Radiation biology initiative/lifesat	(2,000)	15,000	--	--	RD 4-4
Search for extraterrestrial intelligence	11,500	14,500	13,500	13,500	RD 4-7
Research and analysis	44.800	64.700	47,600	55.600	RD 4-8
Total	137.400	183.900	145.800	177.200	

Distribution of Proeram Amount bv Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	47,814	76,038	53,566	68,457
Kennedy Space Center	5,172	8,032	5,532	6,342
Goddard Space Flight Center	570	655	619	723
Jet Propulsion Laboratory	1,525	2,008	1,285	1,501
Ames Research Center	56,503	71,499	58,423	65,133
Langley Research Center	901	738	952	1,112
Stennis Space Center	40	82	48	56
Headquarters	24.875	24.848	25.375	33.876
Total	137.400	183.900	145.800	177.200

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS **SPACE LIFE SCIENCES**

OBJECTIVES AND JUSTIFICATION

The two major goals of the Space Life Sciences program are to develop medical and biological systems which enable human habitation in space, and to advance knowledge about life processes in the universe. Results from the research program are applied to: the immediate needs of maintaining astronaut health and productivity; understanding the response of biological mechanisms to weightlessness; the development of environmental health requirements for space flight, and the design of controlled and bioregenerative life support systems; and understanding the original distribution of life in the universe.

Continuing support of the Space Life Sciences program is essential to: understand the basic biological mechanisms of response to the forces of gravity; evolve the critical technologies necessary to enable long-term piloted space flight; and, develop the capability to sustain a permanent manned presence in space. The research program studies fundamental biological processes through both ground-based and space research efforts which are mutually supportive and integrated,

The Space Life Sciences Research and Analysis program includes five major elements: (1) space medicine, which provides for the physical and environmental health of space crews by seeking to understand and prevent adverse environmental and/or physiological changes which occur in space flight and upon return to Earth; (2) space biology, a multidisciplinary basic research program that studies the fundamental mechanisms of gravitational interaction with all orders of plants and animals in flight and ground experiments; (3) controlled ecological life support systems, a program of research and critical technology development for life support systems necessary to maintain life in space autonomously for long periods of time; (4) exobiology research, which is directed toward understanding the origin and distribution of life and life-related molecules on Earth and throughout the universe; and, (5) biospheric research, which explores the interaction between life on Earth and its physical and chemical environment.

The Space Life Sciences Flight program, consisting of research in human space flight and systems engineering and space biological sciences, provides scientific and engineering support to select, define, develop, and conduct relevant in-space medical and biological experiments related to the microgravity environment. The flight program is actively preparing experiments for launch on Spacelab missions in 1992 and 1993. Definition activities are underway to develop payloads for later Spacelab missions and Space Station Freedom (SSF) utilization. Experiments are currently conducted on the Shuttle and Spacelab, and are being prepared for transition to the SSF. An active international cooperative program with the European Space Agency (ESA), the Centre National d'Etudes Spatiales (CNES), Deutsche Forschungsund Versuchsanstalt fur Luft-und Raumfahrt

(DFVLR), Canadian Space Agency (CSA), the National Space Development Agency of Japan (NASDA), and the former Soviet Union, pursues investigations of common interest. A joint program with the former Soviet Union is aimed at solving biomedical problems associated with long-duration missions. This research is being accomplished utilizing the MIR Space Station in addition to ground-based research.

BASIS OF FY 1993 FUNDING REOUIREMENT

SPACE LIFE SCIENCES FLIGHT PROGRAM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Human space flight and systems engineering	58,300	58,600	70,100	71,400
Space biological sciences	22,800	31,100	14,600	18,300
Centrifuge	(5,100)	(8,200)	(8,200)	18,400
Radiation biology initiative/lifesat	12.000).	15,000	--	--
Total	81.100	104.700	84.700	108.100

OBJECTIVES AND STATUS

The objective of the Space Life Sciences Flight program is to develop payloads designed to expand the understanding of the basic physiological mechanisms involved in adaptation to the space environment, including weightlessness. The program includes selection, definition, in-flight operation, data analysis and reporting on medical and biological investigations involving humans, animals, and plants. Human space flight and systems engineering activities advance NASA's ability to extend the duration, enhance the performance, and improve the safety of human space flight. Past experience indicates that humans clearly undergo physiological changes during weightlessness. Many of the observed changes are physiologically significant, yet are not well understood. Shuttle/Spacelab and the SSF are suitable platforms for gaining a greater understanding of the basic mechanisms underlying these changes. Space biological sciences flight activities use the space environment, especially weightlessness, to further basic understanding of fundamental biological processes. Such flight experiments lead to a better understanding of gravitational adaptation, enhance our basic science knowledge, make it possible to improve life in space and on Earth, and increase the confidence with which we can estimate the physiological consequences of more sustained weightless exposure and design corresponding countermeasures.

FY 1992 activities include the final preparation and flight of approved experiments on two Spacelab missions. International Microgravity Laboratory-1 (IML-1) an international mission including experiments from Canada, France, Germany, Japan, and the United States, scheduled to be launched in January 1992; and Spacelab-J (SL-J) a joint mission between Japan and the United States scheduled for launch in summer 1992. The IML-1 life sciences experiments will study neurovestibular functions, human performance in microgravity, radiation, cell biology, plant biology, and continue gathering data for the Extended Duration Orbiter Medical Program (EDOMP). The SL-J life sciences experiments will study cardiovascular countermeasures, and gravitational biology. Many of the experiments and associated flight hardware flown on earlier Shuttle flights will support and enhance preparations for IML-1, SL-J, and subsequent missions. In addition, five animal and plant experiments will be flown as Shuttle secondary payloads. Life sciences experiments will also be conducted on upcoming Shuttle flights including Spacelab D-2 (SL-D2) a cooperative mission with Germany and Spacelab Life Sciences-2 (SLS-2) the second dedicated life sciences mission.

In FY 1992, under the Human Space Flight and Systems Engineering program, efforts will continue in a major new area of research--ensuring Shuttle crew performance in orbit and upon landing on extended duration orbiter missions. The EDOMP involves investigations on Spacelab and Shuttle middeck experiments with the operational goal of enabling long-duration missions in time for the U.S. Microgravity Lab-1 (USML-1) mission scheduled for launch in 1992. Preparation for the SSF will commence with investigation planning, technology assessment for flight equipment, and critical technology and hardware development.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The FY 1992 program has been reduced by a total of $20.0 million. Funding of $15.9 million for the Lifesat program has been deleted per Congressional direction. The program has additionally been reduced by $5.0 million as part of the Congressionally-directed general reduction to space science and applications. A program realignment has segregated all Spacelab flight program activities into the Human Space Flight and Systems Engineering element. All the SSF activities are now budgeted under Space Biological Sciences, including the Centrifuge, Space Biology Initiative, and Biological Monitoring and Countermeasures (BMAC) programs.

BASIS OF FY 1993 ESTIMATE

Preparations are underway to support several Shuttle/Spacelab missions in FY 1993. Among these are SL-D2 a cooperative mission with Germany and SLS-2 the second dedicated life sciences mission. The SL-D2 life sciences experiments will focus on cardiovascular/fluids. The SLS-2 experiments will focus on cardiovascular, metabolic, musculoskeletal and neurovestibular functions and gather additional data for the EDOMP. In addition, nine animal and plant experiments will be flown as Shuttle secondary payloads.

Efforts will continue on definition and development of new experiments (selected through the Announcement of Opportunity process) and hardware that will be flown on several future Spacelab/Shuttle missions in FY 1993 and beyond - i.e., Shuttle middecks, the German D-3 mission, and the third dedicated life sciences mission (SLS-3). Collaboration with the former Soviet Union on its COSMOS biosatellite program will continue with joint research on COSMOS flights in 1992. In FY 1993, under the Space Biological Sciences program, development will begin on the integrated Centrifuge facility for the SSF. By providing continuous onboard l-G control that can separate influences of weightlessness from other effects of space flight, this facility will support a broad spectrum of life sciences research using small animals and plants. The Centrifuge will allow scientists to test the response of living organisms to operational forces at various stages of adaptation to weightlessness. This facility represents a marked enhancement of basic research capability to the Life Sciences program, and has been a top priority recommendation of the National Academy of Sciences for several years. Activity will continue in the Space Biology Initiative program to determine how the Gravitational Biology Facility (GBF), the Gas Grain Simulation Facility (GGSF) and the Controlled Ecological Life Support System (CELSS) Test Facility will be accommodated on the SSF. Studies will identify unique scientific and hardware transition requirements from continuing Spacelab flights to the SSF operations. In addition, technology assessment, advanced technology development, hardware design and development, and experiment definition and planning will be conducted.

BASIS OF FY 1993 FUNDING REQUIREMENT

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Search for extraterrestrial intelligence	11,500	14,500	13,500	13,500

OBJECTIVES AND STATUS

The Search for Extraterrestrial Intelligence (SETI) microwave observing project will continue hardware fabrication, integration and test in FY 1992. Employing NASA's existing radio astronomy facilities as well as Deep Space Network (DSN) antennas to analyze microwave signals in space for evidence of advanced life elsewhere in the galaxy, SETI promises to be one of the most unique exploration missions ever undertaken. The SETI will be divided between a targeted search in regions of the galaxy with high probability Earth-type systems, and a general survey of the entire sky for non-naturally occurring signals believed to be of intelligent origin.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The FY 1992 program has been reduced by $1.0 million as part of the overall FY 1992 general reduction.

BASIS OF THE FY 1993 ESTIMATE

During FY 1993 the project is scheduled to initiate operations with the prototype targeted search system, continue fabrication, integration and test of the six operational systems including deployment and start up of operational systems 1 and 2. The sky survey prototype will be completing integration and test in preparation for start of initial operations in October 1992. Concurrently, the development of the sky survey operational system will continue to enable full deployment and completion of the observational phase by the year 2000.

BASIS OF FY 1993 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS (LIFE SCIENCES)

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Space life sciences research and analysis	*44,800*	*64,700*	*47,600*	*55,600*

OBJECTIVES AND STATUS

The research and analysis activity supports Space Life Sciences program goals of advancing knowledge in all areas of space life sciences and developing medical and biological systems which enable human habitation in space. The program is composed of five elements: (1) space medicine; (2) space biology; (3) controlled ecological life support systems research; *(4)* exobiology; and, *(5)* biospheric research.

The Space Medicine program is responsible for assuring the physical welfare, performance, and adequate treatment of in-flight illness or injuries of space flight crews. Such conditions as space motion sickness, spatial disorientation, fluid shifts, and endocrine changes, can decrease performance and cardiovascular tolerance and possibly aggravate latent disease. These conditions must be carefully evaluated to determine preventative measures. To this end, careful medical selection, periodic evaluation of health status, and in-flight monitoring of the adaptation to space and success of physiological countermeasures must be continually undertaken. Long-term monitoring of space flight crews will be performed in a standardized fashion in order to identify risk factors and establish the long-term clinical significance associated with repeated exposure to the space environment. Biomedical research investigates the fundamental physiological basis for problems encountered in manned space flight. Research areas include clinical medicine; neuroscience; cardiopulmonary, musculoskeletal, and regulatory physiology; cell and developmental biology; behavior, performance and human factors; and radiation and environmental factors.

The Space Biology program explores the role of gravity in life processes and uses gravity variations as an environmental tool to investigate fundamental biological questions. Specific objectives are to perform the basic science research required to identify and investigate the role of gravity in plant and animal behavior, morphology, development and physiology; the mechanisms of gravity sensing and the transmission of this information within both plants and animals; the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration and disorientation) on the physiology of organisms; the uses of gravity to study the normal nature and properties of living organisms; and, the effects of microgravity on plant and animal growth, long-term survival, and reproduction in space.

The Controlled Ecological Life Support Systems program seeks to provide air, water, and food to support life through a combined physical-chemical-bioregenerative closed system which could receive only energy from the external environment. Development of such systems is a critical path element for program economies during long-duration manned spaceflight and eventual lunar colonization.

The Exobiology program is directed toward understanding the origin and evolution of life, and life-related molecules, on Earth and throughout the universe. Research seeks to trace the pathways leading from the origin of the universe through the major epochs in the evolution of living systems. Research encompasses the cosmic evolution of the biogenic compounds, prebiotic evolution, early evolution of life, and evolution of advanced life. Emphasis is placed on understanding these processes in the context of the planetary and astrophysical environments in which they occurred. Flight experiments in Earth orbit and on planetary missions are important program elements. Theoretical and laboratory investigations are also included in this program to develop a better understanding of the conditions on Earth as related to early chemical and biological evolution.

The Biospheric Research program explores the interaction between global biological and planetary processes to develop an understanding of global biogeochemical cycles. Laboratory and field investigations are correlated with remote sensing data to characterize the influence of biological processes in global dynamics. Biospheric modeling efforts integrate biological data with atmospheric, climate, oceanic, terrestrial, and biogeochemical cycling data to reflect the state of the biosphere as a function of both natural and anthropogenic perturbations.

In FY 1992, the fourth and fifth NASA Specialized Center of Research and Training (NSCORT) will be established at universities to support long-term, broad-based interdisciplinary research on a selected high priority research topic. The NSCORT program, which is modeled on the highly successful National Institutes of Health program, will help increase science results by concentrating resources, facilities and personnel on focused research problems. The NSCORTs will conduct research in the following science programs: biomedical science, operational medicine, space biology, exobiology, and controlled ecological life support systems. Ultimately, the NSCORT program will expand to a total of 10 participating Institutions.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The FY 1992 program has been reduced by a total of $17.1 million, $14.0 million as part of the Congressionally-directed FY 1992 reduction ($10.0 million for cancellation of Space Exploration Initiative (SEI) studies and $4.0 million general Research and Analysis reduction). An additional $3.1 million reduction was also applied to the program, of which $1.1 million was reallocated to Planetary Exploration/Magellan operations and $2.0 million to Commercial Programs to augment the funding requirement for the Commercial Middeck Augmentation Module.

BASIS OF THE FY 1993 ESTIMATE

The Space Medicine program will continue collecting information on occupational exposure in microgravity on each Shuttle flight and conduct in-flight clinical testing of countermeasures, especially in the area of vestibular dysfunction, cardiovascular deconditioning and muscular atrophy. Understanding the dynamics of physiological adaptation to physical forces and being able to measure stress on the human body is crucial to the design of countermeasures to maintain astronaut health and productivity. Research in the fields of psychology and the ergonomics of man/machine interfaces will also be supported. These areas are important to improving the performance and efficiency of flight crews. Research in radiation biology will continue to aim at precisely measuring dosages and the effects of cosmic and solar radiation, with the goal of determining the optimum radiation shielding required for humans in space.

The Space Biology program will concentrate ground research on developing working models of functioning gravity-sensing neural (information) networks to understand neurosensory processing in microgravity; understanding the physiological side effects of centrifugation in preparation for use of the Shuttle/SSF centrifuge as a research tool; and identifying the cellular events of the gravity perception mechanism in plants.

The Controlled Ecological Life Support Systems program will continue to investigate basic biological processes and physical methods to control the interior environment of manned spacecraft. In developing such a life support system, the near-term emphasis will be on system definition and development of design concepts and critical technologies for flight, and supporting research in the areas of controlled-environment plant production, waste processing and human nutrition.

The Exobiology program will emphasize the development of new flight experiment concepts to investigate models of early solar system evolution and mechanisms for the synthesis of biologically significant molecules in space.

The Biospheric Research program will continue investigations of the influence of biological processes in global dynamics and biospheric modeling efforts.

An additional NSCORT selection is expected in FY 1993.

PLANETARY EXPLORATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PLANETARY EXPLORATION

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Ulysses	2,757	--	--	--	
Mars observer	88,528	54,400	76,900	--	RD 5-5
Mars balloon relay	1,497	1,200	1,200	--	RD 5-5
Cassini	143,000	328,000	210,700	210,000	RD 5-7
Mission operations and data analysis	170,152	150,500	156,100	170,300	RD 5-9
Research and analysis	67,766	93,200	90,700	106,900	RD 5-12
Total	473,700	627,300	535,600	487,200	
Distribution of Program Amount by Installation					
Johnson Space Center	12,447	9,400	12,900	13,700	
Marshall Space Flight Center	429	200	800	1,000	
Goddard Space Flight Center	21,596	18,200	11,900	23,600	
Jet Propulsion Laboratory	354,626	535,700	400,900	320,700	
Ames Research Center	15,540	14,100	17,100	10,400	
Langley Research Center	620	--	650	700	
Headquarters	68,442	49,700	91,350	117,100	
Total	473,700	627,300	535,600	487,200	

OBJECTIVES AND JUSTIFICATION

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolutioh of the solar system; (2) to better understand the Earth through comparative studies with the other planets; (3) to understand how the appearance of life in the solar System is related to the chemical history of the solar system; and, (4) to provide a scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been highly successful based on a strategy that places a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the smaller bodies (comets and asteroids). Missions to these bodies start at the level of reconnaissance to achieve a fundamental Characterization of the bodies, and then proceed to levels of more detailed study.

With the Magellan mapping of the Venusfan terrain, the reconhaissance phase of inner planetary exploration which began in the 1960's will be virtually complete. In addition to Magellan, the Pioneer Venus mission continues to study the Earth's nearest neighbor to the point where we have now obtained a basic characterization of Venus' thick, massive atmosphere, as well as fundamental data about the formation of the planet. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of Mars forward to a high level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of meteorites and the lunar rock samples returned by Apollo continue to be highly productive, producing new insights into the early hisaory of the inner solar system and thus leading to revision of our theoretical concepts.

The exploration of the giant outer planets began more recently. The Pioneer-10 and -11 missions to Jupiter in 1973 and 1974 were followed by the Voyager-1 and -2 spacecraft encounters in 1979. Voyager-1 then encountered Saturn in November 1980, with Voyager-2 following in August 1981. The Voyager data on these planets, their satellites, and their rings have revolutionized our concepts about the formation and evolution of the solar system. Voyager-2 encountered Uranus in Januaty 1986 and provided our first look at this giant outer planet. Its trajectory carried it to an encounter with Neptune in August 1989 and provided spectacular images of this mysterious planet and its satellites. In February 1990, Voyager-1 took the first snapshot ever of our solar system. As the Pioneer-10 and -11 and Voyager-1 and -2 spacecraft trajectories take them outside our solar system, they continue to return scientific data about the system's outer region.

Magellan, which was launched in 1989, arrived at Venus in August 1990 and began providing global maps of the cloud-shrouded surface of Venus, including its land forms and geological features. Using a synthetic aperture radar to penetrate the planet's opaque atmosphere, Magellan provides a resolution sufficient to identify small-scale topographical features which address fundamental questions about the origin and evolution of tho planet. Magellan has successfully mapped over 90 percent of the surface of Venus, and is also obtaining altimetry and gravity data to accurately determine the planet's gravity field as well as internal stresses and density variations so that the evolutionary history of Venus can be compared with that of Earth.

Galileo was launched in October 1989. In October 1991, Galileo flew by the asteroid Gaspra, obtaining a spectacular image; the first ever obtained of an asteroid. Additional imagee will be played back when Galileo again flies close to Earth in late 1992. The comprehensive Galileo science payload will extend our knowledge of Jupiter and its system of satellites well beyond the profound discoveries of the preceding Voyager and Pioneer missions. During twenty-two months of operation in the Jovian system, Galileo will inject an instrumented probe into Jupiter's atmosphere to make direct analyses, while the orbiter will have the capability to make as many as ten close encounters with the Galilean satellites.

Ulysses, which was launched in October 1990, is a joint NASA/European Space Agency (ESA) program. The mission carries a package of experiments to investigate the sun at high solar latitudes that cannot be studied from the Earth's orbit. Ulysses is currently en route to Jupiter for a gravity assist maneuver in February 1992. This will enable the spacecraft to turn back towards the sun for a polar pass starting in mid-1994. Management of Ulysses mission operations and data analysis has been transferred to the Physics and Astronomy Mission Operations and Data Analysis (MO&DA) budget in FY 1992 since the data to be collected is of primary interest to the space physics science community.

Mars Observer will build upon the earlier discoveries of Mars by Mariner 9 and Viking and will emphasize the geologic and climatic evolution of this complex planet, This mission will also accommodate the Mars Balloon Relay (MBR) experiment. The French-supplied hardware will be incorporated into tho existing payload and will allow Mars Observer to act as a data relay station for data returned from the balloon stations of the former Soviet Union 1994 Mars mission. Mars Observer will be launched in September 1992, using a Titan III launch vehicle with a Transfer Orbit Stage (TOS) upper stage.

The CRAF/Cassini missions were approved in FY 1990 as the first of a series of missions to conduct detailed observations of the outer solar system. Unfortunately, budget restrictions have resulted in the descoping of CRAF science and the eventual termination of the CRAF mission. Cassini, however, still promises to provide excellent science as it conducts its exploration of the Saturnian system. This will not only enhance our understanding of the large gaseous outer planets, but will also provide new understanding into the origin of the solar system and will help determine whether the necessary building blocks for the chemical evolution of life exist elsewhere in the universe.

Mission operations and data analysis activities continue to support the Voyager-Neptune, Pioneer, Galileo, and Magellan missions. Planetary flight support activities provide ongoing design, development and maintenance of ground support hardware and software for mission control, telemetry and command functions for all planetary spacecraft.

The Research and Analysis program continues to define the scientific priorities for future missions as well as maximizing the exploitation of existing data sets.

BASIS OF FY 1993 FUNDING REQUIREMENT

MARS OBSERVER DEVELOPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	43,020	23,936	33,936	--
Experiments	37,128	21,760	31,760	--
Ground operations	8,380	8,704	11,204	--
Total	88,528	54,400	76,900	--
Mars balloon relay experiment	1,497	1,200	1,200	--
Launch vehicle	(98,300)	(44,200)	(33,200)	--
Upper stage	(12,600)	(11,800)	(11,600)	(200)
Mission operations and data analysis ..	--	--	--	(45,600)

OBJECTIVES AND STATUS

The objectives of the Mars Observer mission are to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation, topography, gravity and magnetic fields of Mars to determine the location of volatile reservoirs and observe their interaction with the Martian environment during all four seasons of the Martian year.

Mars Observer will be launched in September 1992 an a Titan III with a Transfer Orbit Stage (TOS). The spacecraft will be inserted into a near-polar Martian orbit in 1993, from which it will carry out geochemical, geophysical, and climatological mapping of the planet over a period of approximately one Martian year, which is nearly two Earth-years. The Mars Balloon Relay (MBR) experiment will permit a significant increase in the amount of data returned from the balloon stations of the former Soviet Union Mars 1994 mission. Using hardware supplied by the French Space Agency, MBR data will be routed through the Mars Observer Camera (MOC) data stream €or transmission to Earth. MBR operations will be initiated at the conclusion of the Mars Observer nominal mission in 1995.

FY 1992 activities will be focused on delivery of all flight hardware for final system integration and test efforts at GE-Astro. Ground system development is also nearing completion in preparation for operation of the Mars Observer mission after launch. The spacecraft will be delivered to Kennedy Space Center in mid-1992 for integration with the Titan III/TOS launch vehicle.

CHANGES FROM FY 1992 BUDGET ESTIMATE

An additional $22.5 million was included for Mars Observer by Congressional action to support successful completion of integration and test activities necessary to maintain the September 1992 launch.

BASIS OF FY 1993 FUNDING R

CASSINI DEVELOPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	91,300	209,920	134,000	122,700
Experiments	46,800	104,960	68,500	76,800
Ground operations	4,900	13,120	8,200	10,500
Total	143,000	328,000	210,700	210,000
Launch vehicle	(2,400)	(97,100)	(13,300)	(9,300)

OBJECTIVES AND STATUS

During the 1970's, our nation established scientific and technological leadership in exploration of the outer solar system, The initiation of the combined Comet Rendezvous-Asteroid Flyby (CRAF) and Cassini missions, approved for a new start in FY 1990, were initiated in an effort to perpetuate this leadership role. Unfortunately, funding constraints have forced the descoping of CRAF science and eventual cancellation of the CRAF mission as well as the deferral of the Cassini launch by almost two years. Nevertheless, the Cassini program will extend our leadership in important ways during this critical period in solar system science. Cassini will fly past an asteroid en route to Saturn where it will begin a four year study of the Saturnian system. After achieving orbit around Saturn, Cassini will inject the ESA-provided Huygens Probe into the atmosphgre of Saturn's moon Titan, to measure its atmospheric composition, and to provide the first images of Titan's surface. The Huygens Probe represents a major contribution to this mission on the part of our European partners. The orbiting Cassini spacecraft will use radar to map most of Titan's surface.

The Cassini program, building upon the discoveries made through the Pioneer and Voyager missions, will provide unprecedented information on the evolution of our solar system and will help determine whether the necessary building blocks for the chemical evolution of life exist elsewhere in the universe. The Cassini targets (asteroids, Titan, and Saturn system) have a common origin in the outer solar system. The icy conditions on all the small bodies preserve a record of different stages and processes occurring during solar system formation and evolution. Cassini will provide intensive, long-term observation of Saturn's atmosphere, rings, magnetic field, and moons. The Cassini Huygens probe will enable direct physical and chemical analysis of Titan's methane-rich, nitrogen atmosphere which is a possible model for the pre-biotic stage of Earth's atmosphere.

The Cassini program has strong components of international cooperation. The ESA has selected the Cassini Huygens probe as its major new science program at an estimated total cost of $200 million. In addition, ESA member states will contribute approximately $75 million worth of science instruments and scientist participation,

FROM FY 1992 BUDGET ESTIMATE

The current estimate reflects a $117.3 million reduction as directed by Congress which required a 15-month launch delay for CRAF from February 1996 to May 1997 and a 23-month delay of the Cassini launch from November 1995 to October 1997. In FY 1993, budget restrictions have resulted in the termination of the CRAF mission. Consequently, FY 1992 funding will be used to terminate CRAF development activities and to accommodate a major rebaselining exercise for Cassini to reflect the new launch date, new launch trajectories and the transition from a combined mission environment to a single mission scenario. These activities are currently underway, and a revised project plan will be established in early 1992.

BASIS OF FY 1993 ESTIMATE

FY 1993 funding will continue design and development activities of the Cassini spacecraft, ground system and instruments toward Successful completion of several major: design reviews. The ground system Preliminary Design Review (PDR) and the saience instrument and spacecraft subsystem Critical Design Reviews (CDRs) will be completed in 1993 in accordance with the aforementioned launch schedule. CDRs will be conducted for each of the spacecraft subsystems including antenna and radio frequency, power/pyro, attitude and articulation control, command and data, structure, propulsibn, devices, packaging and thermal control. Cassini instrument CDRs will include teviews of up to twelve instruments which are currently in the definition phase, with confirmation planned for 1992 as well as for two Huygens Probe instruments.

The Huygens Probe Hardware Design Review (WHARF) at ESA is also planned for FY 1993, but is subject to change by ESA management pending rebaselining of the overall mission schedule. Also in FY 1993, funding is required for support of the Preliminary Safety Analysis Report (PAR) activities. Signifiaant funding will also be provided to the bepartment of Energy (DOE) for their ongoing Radioisotope Thermoelectric Generator (RTG) develbpment activities.

BASIS OF FY 1993 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1991 Actual	1992 Budget Estimate	1992 Current	1993 Budget Estimate
		(Thousands of Dollars)		
Galileo operations	48,074	57,700	57,700	63,000
Magellan operations	43,300	29,200	38,200	7,000
Ulysses operations	7,977	--	--	--
Mars observer operations	--	--	--	45,600
Pioneer operations	9,560	10,900	10,600	--
Voyager/Neptune data analysis	3,400	5,700	5,700	6,000
Voyager interstellar mission	14,177	--	--	--
Planetary flight support	43.664	47.000	43.900	48.700
Total	170.152	150.500	156.100	170.300

OBJECTIVES AND STATUS

The objectives of the planetary mission operations and data analysis program are in-flight operation of planetary spacecraft and the analysis of data from these missions. The planetary flight support line funds the design and development of planetary flight operation ground systems, and other activities that support the mission control, tracking, telemetry, and command functions through the Deep Space Network for all planetary spacecraft.

Operations for Galileo began in FY 1990 for the spacecraft's 6-year journey to Jupiter. Galileo was launched in October 1989 and will arrive at Jupiter in 1995 where it will conduct a comprehensive exploration of the Jovian System. The recent flyby of Gaspra in October 1991 provided us with the first images ever taken of an asteroid. Additional images will be returned when the spacecraft again approaches Earth for its final gravity assist en route to Jupiter. Work continues in an attempt to fully deploy the High Gain Antenna (HG). A series of warming and cooling turns are being planned for the next several months.

Operations continue for the Magellan spacecraft which was launched in May 1989. Since its arrival at Venus in August 1990, the spacecraft has mapped a major portion of the planet to a ground resolution of about 150 meters. This has been combined with altimetry data to produce dramatic three-dimensional imagery of the planet's surface topography. The initial mapping cycle was completed in May 1991. A second mapping cycle is currently underway which is providing enhanced imagery and filling gaps in the data from the first cycle. The second mapping cycle will be completed in January 1992. Funds have been provided for a third cycle, which will extend operations through September 1992 and will not only provide further enhancements to the existing imagery, but will also obtain important gravity data as well.

Operations for Ulysses began in FY 1991 for the ESA spacecraft's mission to the polar regions of the sun. Ulysses was launched in October 1990 and will arrive at Jupiter in February 1992 for a gravity assist maneuver which will enable the spacecraft to make a polar pass around the Sun beginning in mid-1994. In FY 1992, management of Ulysses operations was transferred to the Physics and Astronomy (Space Physics) MO&DA budget since the data obtained is of primary importance to the space physics science community.

FY 1992 funds also support analysis of data acquired during the Voyager-2 Neptune encounter of August 1989. This flyby of Neptune provided our first detailed images of this distant planet. Highlights of this encounter included discovery of several previously unknown moons, and geyser-like surface eruptions. Continued Voyager-Neptune data analysis will provide further insight into the origin and evolution of the solar system and will complement the science to be obtained from both Galileo and Cassini. Voyager-2, now designated the Voyager Interstellar Mission (VIM), continues on a trajectory beyond the solar system. As with Ulysses, support for this mission has been transferred to the Physics and Astronomy (Space Physics) MO&DA budget since the science to be obtained at this point is of primary interest to the space physics science community.

Pioneers-10 and -11 continue to explore the outermost edge of the solar system. Pioneer-10 will encounter the unexplored region beyond Pluto where the sun's influence is secondary to those of true interstellar space. These spacecraft will continue the search for gravitational evidence of a tenth planet. Pioneers 6-9 continue to collect information on the interplanetary magnetic field and solar wind as they orbit the Sun. The Pioneer Venus orbiter continues to obtain data on the Venusian atmosphere and magnetosphere and its interaction with the solar wind.

CHANGES FROM FY 99 BUDGET ESTIMATE

The current estimate, which increased net FY 1992 funding by ***$5.6*** million, reflects an increase of $9.0 million €or continued Magellan operations. As indicated in the initial operating plan, this increase has been partially offset by decreases to the Pioneer program and to Planetary Flight Support. These Magellan funds will support initiation of a third mapping cycle, which Continues through September 1992. Additional funds will be required to complete this cycle and will Be addressed in a subsequent operating plan adjustment. Operational responsibilities for the Ulysses and Voyager Interstellar Missions have been transferred to Physics and Astronomy in FY 1992.

BASIS OF FY 1993 ESTIMATE

FY 1993 funding is required to support ongoing mission operations activities for Galileo. Following a second Earth gravity assist in December 1992, an encounter with a second asteroid, Ida, is also tentatively planned in August 1993 as the spacecraft approaches the outer solar system. Software command puling and mission sequence development activities continue in preparation for arrival at Jupiter in December 1995. Post-flight data analysis activities will begin for Magellan upon completion of a third mapping cycle in September 1992. Funding for Mars Observer operations will begin following a launch in September 1992. Planned activities include initial spacecraft and instrument checkout and continued software and mission sequence development as the spacecraft is prepared for arrival at Mars in August 1993. Planetary flight support and Voyager-Neptune data analysis activities are also ongoing.

BASIS OF FY 1993 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Supporting research and technology	55,566	74,200	67,800	72,700
Advanced programs	5,100	14,700	14,700	25,400
Mars data analysis	7,100	4,300	8,200	8,800
Total	67.766	93.200	90.700	106.900

OBJECTIVES AND STATUS

The research and analysis program consists of three elements: (1) to assure that data and samples returned from flight missions are fully exploited; (2) to undertake complementary laboratory and theoretical efforts; and (3) to define science rationale and develop required technology to undertake future planetary missions.

The supporting research and technology activity includes planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, interdisciplinary studies, and U.S. scientist participation on foreign missions.

The planetary astronomy activity includes all observations made by ground-based telescopes of solar system bodies, excluding the sun. Emphasis is on the outermost planets, comets and asteroids. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high, and the data acquired is used both for basic research in support of planetary program objectives and for direct support of specific flight missions. The planetary astronomy funding also provides for the continued operation of the Infrared Telescope Facility in Hawaii. The planetary atmospheres activity includes data analysis, laboratory, and theoretical efforts. The properties of other planetary atmospheres are amenable to measurement with planetary spacecraft and can aid us in better understanding our own weather and climate. Observations of the atmospheres of Venus, Jupiter, Saturn, Uranus and Neptune acquired by Pioneer Venus and Voyager, have laid the basic observational ground work for major advances in this field.

The planetary geology/geophysics activity is a broadly scooped program that includes the study of surface processes, structure, and history of solid components (including rings) of the solar system and investigation of the interior properties and processes of all solar system bodies, both solid and gaseous. This program emphasizes comparative studies to gain a fundamental understanding of the physical processes and laws which control the development and evolution of all planetary bodies, including the Earth. In this respect, data from the Magellan mission is of crucial importance.

The planetary materials/geochemistry ac ivity supports an active scientific effor to determine the chemistry, mineral composition, age, physical properties and other characteristics of solid material in the solar system through the study of returned lunar samples and meteorites and through laboratory and theoretical studies of appropriate geochemical problems. Extraterrestrial dust grains, collected for analysis, continue to yield new and otherwise unobtainable information about the solar system and its early history. This program is coordinated with the lunar sample and meteorite research, which is supported by other agencies, such as the National Science Foundation (NSF). The operation of the Lunar Curatorial Facility is also supported by this activity.

The objective of the advanced program activity is to provide adequate planning and preparation for future planetary missions which will ensure the systematic exploration of the solar system on a scientifically and technically sound basis. The instrument definition activity seeks to maximize scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation, which are optimized for such missions.

The Mars data analysis program continues to support analysis of data obtained by Viking and earlier missions so that we are scientifically prepared for the next phase of Mars exploration. Establishment of a Planetary Data System (DPS) which will permit the archiving of these and all other data products in a manner which will promote and facilitate their use, is also supported.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Funding for Supporting Research and Technology was reduced to accommodate a $1.0 million Congressionally-directed reduction yet still maintains a 19 percent increase over FY 1991. An additional $1.5M was transferred to Planetary Mission Operations and Data Analysis to support continued Magellan operations. Within this activity, the funding for Mars data analysis has been increased in FY 1992 to provide for a similar level of activity as that funded in FY 1991.

BASIS OF FY 1993 ESTIMATE

During FY 1993, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, Mars data analysis, and advanced technology development for future missions. Ground telescope observations will provide data complementary to that obtained from the flight missions, with emphasis on the outermost planets, comets and asteroids. Funding will also support the upgrading and modernization of ground-based laboratory instrumentation in order to reduce maintenance costs and down-time and to improve capabilities.

Instrument definition activities will continue to support development of new state-of-the-art instruments for future missions. The Mars data analysis Program will support continued analysis of Mars data in preparation for new Mars missions, and development of the Planetary Data System to archive all planetary data for enhanced accessibility for all users will continue.

During FY 1993, research will also continue in the study of origins of solar system to gain an understanding of the origin and evolution of planetary systems, and the paths of various elements and compounds throughout that evolution. Funding has also been included to conduct studies of small satellite technologies for future planetary missions. This program will examine the feasibility of using small (i.e., Delta-class) spacecraft with high technological inheritance and limited science payloads of two or three instruments in an effort to develop low-cost, scientifically viable missions with short development schedules. Candidate missions include asteroid encounters, lunar exploration and Earth-orbiting planetary telescopes.

EARTH SCIENCE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — EARTH SCIENCE AND APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Earth observing system	150,600	253,400	184,400	308,400	RD 6-6
Earth observing system data information system	36,000	82,600	82,600	82,600	RD 6-9
Earth probes (including Scatterometer)	51,700	68,200	92,800	88,900	RD 6-11
Remotely piloted aircraft	--	5,000	--	--	
Upper atmosphere research satellite mission	62,000	18,200	--	--	RD 6-13
Ocean topography experiment	80,400	51,900	59,900	--	RD 6-14
Payload and instrument development	49,100	48,600	39,600	49,400	RD 6-15
Mission operations and data analysis ..	39,400	56,300	83,800	142,100	RD 6-17
Interdisciplinary research	12,400	2,500	2,500	2,600	RD 6-20
Modeling and data analysis	44,300	45,000	49,000	45,000	RD 6-21
Process studies	116,200	123,300	123,600	126,600	RD 6-24
Airborne science and applications	20.200	20,600	20.300	22.900	RD 6-28
Total	662.300	775,600	738.500	868.500	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

EARTH SCIENCE AND APPLICATIONS

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	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Marshall Space Flight Center..........	11,169	11,800	11,800	13,797
Goddard Space Flight Center	344,980	430,400	349,288	410,909
Jet Propulsion Laboratory	163,679	210,360	212,360	250,805
Ames Research Center	28,032	44,420	44,420	51,939
Langley Research Center	26,816	31,780	31,780	37,159
Stennis Space Center	369	730	730	853
Kennedy Space Center	75	--	--	--
Headquarters	87.180	46,110	88.122	103.038
Total	662.300	775,600	738.500	868.500

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

OBJECTIVES AND JUSTIFICATION

The on-going NASA program is making critical near-term contributions to understanding the Earth as an integrated system as well as to environmental issues including global warming and ozone depletion. NASA's base program combines ground-based measurements, laboratory studies, data analysis and model development with a progressive series of satellite missions, and support to the scientific research base in ozone monitoring, ocean circulation, and atmospheric chemistry.

The ability to measure the extent of both the natural and man-induced changes in our global ecosystem is only a preliminary step - the capability to model and predict the consequences of global change is the ultimate objective. The U.S. Global Change Research Program (USGCRP), in which NASA has been a major participant, was initiated in early 1989 in order to provide a focused and effective mechanism for coordinating and directing federally funded Earth science research.

The specific objectives of the NASA Earth science and applications program are to improve our understanding of the processes in the atmosphere, oceans, land surface and interior of the Earth, and advance our knowledge of the interactions between these environments. The program provides space observations of parameters involved in these processes and extends the national capabilities to predict environmental phenomena, both short and long term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes only, observed from space. NASA's programs include scientific research efforts as well as the development of new technology for global and synoptic measurements. NASA's research satellites, Shuttle/Spacelab payload program and airborne science and applications program provide a unique view of the planet Earth, its physical dynamics, and radiative and chemical processes which affect habitability and the solar-terrestrial environment.

A number of significant objectives have been established for the next decade. These include advancing our understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; characterizing the current state of the terrestrial landscape, including the biosphere and the hydrosphere; optimizing the use of space-derived measurements in understanding large scale weather patterns; advancing our knowledge of severe storms and forecasting capabilities, ocean productivity, circulation, and air-sea interactions; and improving the knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction, Studies of the cycling of key biogeochemical elements, interactions between the biosphere and the climate system, the composition and evolution of the crust and the processes that shape the crust are essential to our understanding of the global environment.

Effective u ilization of remo e sensing requires a balanced set of activities including: analytical modeling and simulation; laboratory research of fundamental processes; development of instrumentation, flight of the instruments on the Space Shuttle, research satellites and airborne platforms; collection of in situ ancillary or validation data; and scientific analysis of data. The approach is to develop a technological capability with a strong scientific base and then collect appropriate data through remote and in situ means, which will address specific program objectives.

The Earth Observing System's primary objective is to document global change and to observe regional-to-global scale processes. Utilizing several satellites, the EOS will document global change over a fifteen-year period to provide long-term, consistent data sets for use in modeling and understanding global processes. This process and modeling research effort will provide the basis for establishing predictive global change models which may be used by policy makers and scientists in formulating strategies to manage human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation.

The Earth probes program, as a part of the Mission to Planet Earth, is designed to provide small, specialized satellites to complement data gathered by the Earth Observing System. These satellites require special orbits and spacecraft capabilities and will provide data on tropical rainfall (Tropical Rainfall Measurement Mission (TRMM)), and ocean wind speed and direction (NASA Scatterometer), both necessary for better understanding global climate systems. In addition, satellites will be orbited to collect data on global ozone concentrations (Total Ozone Mapping Spectrometer (TOMS)).

The Upper Atmospheric Research Satellite (UARS), launched in September 1991, placed a set of instruments in Earth orbit that will make comprehensive measurements of the stratosphere, providing data about the Earth's upper atmosphere in spatial and temporal dimensions which were previously unobtainable.

Development and launch of the Ocean Topography Experiment (TOPEX) will be completed in FY 1992. The objective of the TOPEX is to acquire precise observations of the surface topography of the ocean. These data, in conjunction with Scatterometer, will enable the first determination of the wind forcing and ocean current response of the global oceans. Spacecraft integration and checkout efforts are underway, leading to a July 1992 launch.

The objectives of the payload and instrument development program are to develop, test and evaluate Earth-viewing remote sensing instruments and systems to obtain data necessary to conduct basic research projects as well as provide correlative and developmental feasibility information for major free-flying spacecraft. Current instrument developments include the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS); Active Cavity Radar (ACR); Light Detection and Ranging (LIDAR); and Shuttle Imaging Radar-C (SIR-C).

Beginning in FY 1992, the mission operations and data analysis program will begin collecting data from the UARS and TOPEX missions. Ocean color data for research use will also be obtained from a spacecraft to be launched in 1993. This imaging data will be processed and archived, resulting in long-term data sets related to the biological productivity and ecology of oceans, seas, and larger lakes. The Nimbus spacecraft continues to collect unique data which is being used in the study of long-term trends of the Earth's atmosphere, oceans and polar ice, and provides near-real-time data. The Earth Radiation Budget Experiment (ERBE) was successfully launched in 1984 and continues to provide valuable data.

The interdisciplinary research program will continue integrating discipline-specific research activities into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific pilot studies, such as those concerning processes controlling atmospheric methane concentrations, changes in land surface properties and their effect on climate, and the role of oceans in the global carbon cycle.

The modeling and data analysis program will focus on developing predictive models for global change and analyzing data sets to determine mechanisms at work in the global environment. The program will focus on two major areas - physical climate and hydrological systems, and biogeochemistry and geophysics.

The process studies program will utilize a variety of techniques to develop an understanding of the processes at work in the global environment and to determine interdependencies which may impact global change management strategies. The program will utilize existing data sets and will conduct field experiments which will enable researchers to better understand global environmental dynamics. Process studies concentrate on four major interdisciplinary categories - radiation dynamics and hydrology; ecosystem dynamics and biogeochemical cycles; atmospheric chemistry; and solid Earth science, including operation of the laser research facilities.

The airborne science and applications program has previously provided platforms for observing ozone-depleting reactions in the atmosphere above the Arctic. This effort was a follow-on to the previous expeditions to the Antarctic. In addition, the airborne program has provided platforms for such diverse studies as soil moisture measurements, atmospheric pollutants detection, vegetation studies and studies in geology. In addition to this continuing research, the FY 1992 program will focus on providing flights for precursor EOS instruments in order to develop and refine techniques for measuring environmental change.

BASIS FOR FY 1993 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Instruments	79,000	159,900	123,000	--
Observatories	55,600	58,500	30,200	--
Science	16,000	35,000	31,200	--
AM series	--	--	--	241,500
PM series	--	--	--	30,900
Chemistry	--	--	--	6,800
Small spacecraft	--	--	--	11,200
Interdisciplinary science	--	--	--	18.000
Total	150.600	253,400	184,400	308,400
Launch vehicles	--	--	--	(2,900)

OBJECTIVES AND STATUS

The objective of the Earth Observing System (EOS) is to acquire a long-term set of comprehensive measurements of various aspects of the Earth system. The EOS program will provide the basis for predictive global change models to be used by policy makers and scientists in formulating strategies to mitigate human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation. The EOS program fulfills the science requirements of the Intergovernmental Panel on Climate Change (IPCC).

During 1991, the EOS program was completely restructured to conform to Congressional guidance and the results of the External Engineering Review. The restructured EOS program includes five U.S. missions; the AM, PM, Chemistry, Altimetry, and Aerosol series; the possible flights of some instruments on Japanese and European spacecraft; an ocean color data purchase; and supporting science. Each of the five flight series will be designed to last five years, flying three times in order to make measurements over a fifteen year period. The role of the restructured EOS program has been tightly focused on the scientific understanding of global climate change. The details of the restructured program will be presented to the Congress in a report in early 1992.

The EOS will provide comprehensive measurements of the nature of global climate change. The AM series science objectives are to measure physical and radiative properties of clouds; air-land exchanges of energy, carbon, and water; and vertical profiles of carbon monoxide and methane. The PM series will study cloud formation, precipitation, and radiative properties; air-sea fluxes of energy and moisture; and sea-ice extent and heat exchange with the atmosphere. The remaining EOS missions will examine aerosol and chemical properties of the troposphere and stratosphere, ocean altimetry and circulation, and ice sheet mass balance.

The EOS missions will monitor many parameters that are indicators of the state of the environment, such as the spatial and temporal distribution of tropospheric and lower stratospheric gases. In addition, interdisciplinary theoretical investigations will be conducted to utilize the EOS data sets to study such phenomena as ecosystem distributions and conditions; biogeochemical fluxes at the ocean-atmosphere and land-atmosphere interfaces; the global carbon cycle; and atmospheric composition.

The five series have been designed as unique spacecraft to capture the data. The AM series, with a morning equatorial crossing, the PM series, with an afternoon equatorial crossing, and the Chemistry series will fly as intermediate-size spacecraft. The other missions will be flown as small spacecraft.

CHANGES FROM FY 1992 BUDGET ESTIMATE

In FY 1992, the EOS was reduced by $69.0 million, of which $65.0 million was based on Congressional direction. $4.0 million was reallocated to the Scatterometer to maintain the delivery schedule in support of the launch.

BASIS OF FY 1993 ESTIMATES

The EOS budget has been restructured to conform to the new EOS program. Beginning in FY 1993, the AM, PM, and Chemistry series budgets include development costs unique to the series such as instruments, spacecraft, science computing facilities, science product capability development, and mission science. Development costs will be through launch plus thirty days in-flight checkout. Mission operations and data analysis will include all costs associated with the flight after development. Interdisciplinary science includes funding for the selected interdisciplinary science investigators, science computing facilities for them, and the EOS fellowship program.

During FY 1993, all aspects of the AM-1 flight development will be fully underway, The AM-1 instruments (Clouds and the Earth's Radiant Energy System (CERES), Moderate-Resolution Imaging Spectrometer-Nadir (MODIS-N), Multi-Angle Imaging Spectra-Radiometer (MISR), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and Measurements of Pollution in the Troposphere (MOPITT)) will complete Preliminary Design Reviews (PDR's). The ASTER and MOPITT are being developed by Japan and Canada respectively. The system level PDR for the AM-1 spacecraft will also be conducted in FY 1993.

Preliminary design activities will continue on the instruments planned for the PM-1, Chemistry, Altimetry, and Aerosol flights. Of particular importance is the need to maintain progress on the development of the Atmospheric Infrared Sounder (AIRS), High-Resolution Dynamics Limb Sounder (HIRDLS), and Scatterometer (STIKSCAT), efforts that are technologically demanding and have been underway since their initial selection for EOS-A1 in FY 1991. The HIRDLS instrument will be developed as a joint United Kingdom and U.S. project. A request for proposals for award of the development contract of the second EOS spacecraft (PM-1) will be released in FY 1993.

FY 1993 funding is required for continued EOS science principal investigators and science facility team support. These funds are critical to the continued development of the EOS science and analysis algorithms that will produce the data products from the science instruments.

BASIS FOR FY 1993 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Earth observing system data information system	36,000	82,600	82,600	82,600

OBJECTIVES AND STATUS

A key element enabling the Earth Observing System (EOS) to meet the long-term science goals of the program, and those of Mission to Plant Earth, is the EOS Data and Information System (EOSDIS). The EOSDIS will provide the processing, storage, and distribution of all the science data collected by EOS as well as the resulting scientific products. The EOSDIS system will also have the capability for spacecraft and instrument command and control. Additionally, EOSDIS will provide data archive, distribution, and information management for all NASA Earth science data.

The EOSDIS is designed to be evolutionary with capability phased to support the requirements of the restructured EOS program and those of other Earth science spacecraft and data sources. The plans for EOSDIS will be independently reviewed in 1992 by the National Academy of Sciences. The EOSDIS will be implemented as a distributed system, with a network of Distributed Active Archive Centers (DAACs) and experts developing science tools in designated disciplines. The DAACs will perform continuous processing of instrument data to derive the underlying scientific parameters of interest. The network will link the archived data and products so that investigators may access the entire set of holdings from any entry point. An information management service will help users locate data within the total archive. The network also will interface with international partner instruments and control facilities and will provide operational data to agencies such as NOAA.

The EOSDIS includes a comprehensive data system called the EOS Data Operations and Communications System (EDOCS) that accepfs data from the Tracking And Data Relay Satellite System (TDRSS) ground terminal, processes it, and delivers data products to the scientists through the EOSDIS. The EOS data functions formerly planned in the Office of Space Communications as the Customer and Data Operations System (CDOS) are now part of EOS.

The EOSDIS will be implemented by a core system contractor, with contract award planned for late 1992. Preliminary work by NASA will establish a Version 0 EOSDIS, providing researchers with early access to data sets from EOS precursor missions and from Earth probes to be flown before EOS.

BASIS OF FY 1993 ESTIMATE

The EOSDIS budget has been restructured. The mission-unique science computing facilities and science product capabflity development are now part of the EOS flight series budgets, i.e., AM series, PM series, etc.

FY 1993 funding is required for continued development of EOSDIS Version 0 pathfinder data sets and for operation of NASA's existing Earth science data system elements. The EOSDIS competitive core system contract will be awarded in FY 1993. The EOSDIS funding for the independent verification and validation activities will begin approximately six months after the award of the EOSDIS core system contract. The EOS data operations contract will be awarded in FY 1993. The EOS systems requirements review will be in FY 1993 in preparation of the EOSDIS design.

BASIS FOR FY 1993 FUNDING REQUIREMENT

EARTH PROBES

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Scatterometer	20,700	24,000	28,000	20,200
Total ozone mapping spectrometer......	16,000	29,900	30,800	18,700
Tropical rainfall measurement mission.	15,000	14,300	19,000	50,000
Climsat	--	—	15,000	—
Total	51,700	68,200	92,800	88,900
Launch vehicles (TOMS).................	(1,700)	(12,100)	(6,000)	(1,200)

OBJECTIVES AND STATUS

The Earth probes program is a component of Mission to Planet Earth that addresses specific, highly-focused problems in Earth science. The program has the flexibility to take advantage of unique opportunities presented by international cooperative efforts or technical innovation. The Earth probes complement the Earth Observing System program by providing the ability to investigate processes which require special orbits or have other requirements such as a magnetically clean spacecraft for future gravitational investigations.

The planned Earth probes are the Total Ozone Mapping Spectrometer (TOMS), NASA Scatterometer (NSCAT), Tropical Rainfall Measurement Mission (TRMM), and Climsat. The TOMS is a set of instruments that will be flown on free-flyers planned for launch on small class vehicles in 1993 and 1997, and on the Japanese Advanced Earth Observing System (ADEOS) Satellite in 1995. The NSCAT is also planned for launch on the Japanese ADEOS satellite. The TRMM is planned for launch in 1997. The Climsat is a global climate change mission to be launched in the 1995 or 1996 timeframe.

The NSCAT will provide accurate, global measurements of ocean surface winds which will be useful for both oceanography and meteorology. In addition to providing wind field data, NSCAT data will permit the first global study of the influence of winds on ocean circulation, providing data on the effects of the oceans on the atmosphere and improved marine forecasting on winds and waves.

The TOMS instrument will provide uninterrupted data on total atmospheric ozone concentrations. Collection of this data was begun in 1978 with the launch of a TOMS instrument on Nimbus-7.

The TRMM will measure precipitation in the tropical latitudes from a dedicated Earth probe. The spacecraft, integration and some instruments will be provided by the United States. The launch vehicle and the rain radar will be provided by the Japanese. The current plan is for launch in **1997**.

CHANGES FROM FY 1992 BUDGET ESTIMATE

In **FY 1992**, Earth probes were increased by ***$24.6*** million. Increases for Climsat, $15.0 million, and TRMM, **$5.0** million (less **$.3** million contractor conversion adjustment), were directed by the Congress. Funding for the Scatterometer was increased by $4.0 million to support ongoing hardware and software development. The TOMS was also increased by $1 million (less $0.1 million contractor conversion adjustment) to maintain launch schedule for a **1993** launch.

BASIS OF FY 1993 ESTIMATE

FY 1993 funding is required to continue development of the NSCAT which is currently scheduled for a February **1995** launch. In **FY 1993**, NSCAT instrument integration, testing, and calibration will be the key project focus. **FY 1993** funding is also required to complete development of the first TOMS free-flyer The system design and development will be completed and launch preparation will begin in FY **1993**. In addition, work will continue on the follow-on TOMS missions in **1995** and **1997**. Development of TRMM will proceed in **FY 1993** with the critical design review for spacecraft and instrument design in October **1993**. The Climsat program will be developed and managed by the Department of Energy.

BASIS OF FY 1993 FUNDING REQUIREMENT

UPPER ATMOSPHERE RESEARCH SATELLITE PROGRAM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	15,200	3,500	--	--
Experiments	46,800	14,700	--	--
Total	62,000	18,200	--	--
Mission operations and data analysis	(--)	(17,200)	(17,200)	(35,400)
STS operations	(26,900)	(34,200)	(--)	(--)

OBJECTIVES AND STATUS

The Upper Atmosphere Research Satellite (UARS) mission, launched in September 1991, is essential for understanding the key radiative, chemical and dynamic processes which couple together to control the composition and structure of the stratosphere. The UARS mission is providing the first integrated global measurements of: ozone concentration; chemical species that affect ozone; energy inputs; temperature; and winds in the stratosphere and mesosphere. The ten UARS experiments include infrared and microwave limb sounders which required advances beyond earlier capabilities in cryogenics, solid-state devices and microwave antennas. The ground data handling facility will enable a higher level of interaction among experimenters and theoreticians than has existed with past programs.

CHANGES FROM FY 1992 BUDGET ESTIMATE

In FY 1992, $18.2 million for UARS development was eliminated in accordance with Congressional direction.

BASIS OF FY 1993 FUNDING REQUIREMENT

CEAN TOPOGRAPHY EXPERIMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Ocean topography experiment (TOPEX) ...	80,400	51,900	59,900	--
Mission operations and data analysis ..	(--)	(5,000)	(5,000)	(29,000)

JECT AND STATUS

The goal of the Ocean Topography Experiment (TOPEX) is to utilize satellite radar altimetry to measure the surface topography of the global oceans over a period of three years with sufficient accuracy and precision to enhance our understanding of the oceans' general circulation and mesoscale variability. The capability of satellite altimetry to address this goal was demonstrated in 1978 by the NASA Seasat program. Such information is needed to understand how the atmosphere drives the circulation of the oceans, how the oceans in turn influence the atmosphere, and, ultimately, the role of the oceans in climate.

NASA and the French Space Agency (CNES) are collaborating on TOPEX in order to exploit the scientific value of the data. In exchange for scientific collaboration, the flight of a French altimeter aboard TOPEX, and tracking system, CNES will launch TOPEX in July 1992 on an Ariane 4 launch vehicle. TOPEX is also planned in concert with the World Ocean Circulation Experiment (WOCE), a major international oceanographic field program under the auspices of the World Climate Research Program (WCRP). The WOCE will combine satellite observations from TOPEX with in situ observations to enable the first comprehensive determination of the three-dimensional current structure of the global oceans. When further combined with ocean surface winds data from the NASA Scatterometer (NSCAT), unique measurements of the oceans' driving force (winds) and the resulting ocean response (topography) will have been obtained.

During 1992, the satellite contractor will complete the development phase. After conclusion of integration and test functions, the spacecraft and sensors will be delivered to the launch site, Kourou, French Guiana, in April 1992 for integration into the Ariane 4 launch vehicle. The joint NASA/CNES science team will finish development and verification of algorithms needed to produce consistent mission data products.

CHANGES FROM FY 1992 BUDGET ESTIMATE

An additional $8.0 million was added to the TOPEX program to maintain critical schedules leading to launch in July 1992.

BASIS FOR FY 1993 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Atmospheric payloads	13,700	14,600	13,600	15,500
Earth sensing payloads	31,700	34,000	26,000	33,900
EOS ATD	3,700	--	--	--
Total	49,100	48,600	39,600	49,400

OBJECTIVES AND STATUS

The Space Transportation System (STS) offers a unique opportunity for short-duration flights of instruments. The Earth science and applications program has incorporated this capability into the Shuttle/Spacelab payload development activities in these important aspects: early test, checkout and design of remote sensing instruments for long-duration, free-flying missions and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical. Instrument development activities support a wide range of instrumentation, from airborne to international flights of opportunity.

The objective of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument flew in 1985 on Spacelab-3. The science results from the first flight of ATMOS were of exceptional value, and the basic capability of ATMOS to measure very low concentrations of trace species in the Earth's atmosphere was clearly demonstrated.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas-filter correlation radiometer designed to measure the levels of troposphere carbon monoxide and the extent of inter-hemispheric mass transport in the lower atmosphere. The instrument was flown successfully on two Shuttle flights. It is planned for three more STS flights, to provide the first observations of the global seasonal variation of carbon monoxide in the Earth's atmosphere. Reflight of MAPS is also planned on the Shuttle Radar Laboratory (SRL) series.

The Active Cavity Radiometer-1 (ACR-1) is designed to aid in the study of the Earth's climate and the physical behavior of the sun by making solar constant measurements. Reflights of ACR-1 on the ATLAS series are planned.

Components of the Shuttle Imaging Radar-B (SIR-B) will be used in building the next generation imaging radar instrument, SIR-C. The SIR-C will use multi-polarized, dual-frequency sensor technology. The SIR-C is in the development and fabrication phase. System requirements review, antenna preliminary design review and system preliminary and critical design reviews are now complete. Flight aboard the Space Shuttle is scheduled for late 1993. In October 1987, NASA signed a Memorandum of Understanding with Germany agreeing to joint missions of SIR-C with an x-band imaging radar to be provided by a joint German/Italian project (X-SAR).

Advanced spectrometer technology development activities include fundamental research in remote sensing involving airborne and spaceborne imaging spectrometer instruments. The imaging spectrometer and linear array solid-state sensor research focuses on the development of such features as inherent geometric and spectral registration and programmable high spatial and spectral resolution.

BASIS OF FY 1992 BUDGET ESTIMATE

A reduction of $8.0 million was made to the Earth sensing payloads program to provide funds for TOPEX. In addition, the atmospherics payloads program was reduced by $1.0 million to support Earth probes (TOMS) development tasks. These reductions will be accommodated through deferral of advanced development activities.

BASIS OF FY 1993 ESTIMATE

FY 1993 funds will be used to support the MAPS science team activities including data reduction, refurbishment for reflight and upgrading of the ground service equipment. The FY 1993 funding for ATMOS is required to support continuing flight of the ATLAS series, including continued science team activities, data processing and analysis, and limited refurbishment. FY 1993 funding is also required to continue the ACR data processing, science team activities, and refurbishment for reflight on future Shuttle ATLAS flights.

Development activities will continue on the international (U.S. and France) Light Detection and Ranging (LIDAR) airborne instrumentation following completion of critical design reviews in preparation for the integration and ground test of this multi-phase user program. First flight is projected for FY 1993. In this program, both NASA and France are supplying science knowledge to demonstrate first-time detail measurements of the atmosphere to aid in forecasting.

In FY 1993, funding is required for continued development, integration and checkout of SIR-C, in preparation for its launch in 1993. In 1992, all instrument integration and performance testing will be completed, as will testing of the antenna to the instrument. By October 1992, the thermal vacuum test will be done and the instrument will be prepared for delivery to the launch site.

BASIS OF FY 1993 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Upper atmospheric research satellite operations.	--	17,200	17,200	35,400
Ocean topographic experiment operations	--	5,000	5,000	29,000
Ocean color mission data purchase	9,000	13,000	13,000	14,900
Consortium for international earth science information networks	a,000	--	25,000	--
Landsat	--	--	2,500	25,000
Earth sciences mission operations and data analysis	22,400	21,100	21,100	37,800
Total	39,400	56,300	83,800	142,100

OBJECTIVES AND STATUS

The objective of the Earth science and applications mission operations and data analysis program is to acquire, process, and archive long-term data sets produced by spaceborne missions. These data relate to issues of global change in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for operations of spacecraft, processing of acquired data, validation of the resulting data products by science teams, and development of new processing software by these science teams.

The Upper Atmosphere Research Satellite (UARS) was launched in September 1991. The mission is providing data related to the chemistry and dynamics of the atmosphere above the tropopause for a period of at least three years. Various instruments aboard UARS are measuring temperature, composition, and winds in the Earth's atmosphere, as a function of altitude, over ninety-eight percent of the Earth's surface, from eighty degrees South latitude to eighty degrees North. These data will provide important information related to maintenance and destruction of the ozone layer.

NASA's Ocean Topography Experiment (TOPEX) and the Poseidon mission of France's CNES, will be launched as a single ocean spacecraft mission, TOPEX/Poseidon, in July 1992. After launch, this mission will provide data on the surface topography and currents of the Earth's oceans for a period of at least three years. These data will provide critical information related to the circulation of the Earth's oceans and the Earth's climate.

NASA will purchase ocean color data for research use, to be obtained from a spacecraft to be launched in 1992 or 1993. This imaging data, to be obtained in several visible wavelengths, will be processed and archived, resulting in long-term data sets related to the biological productivity and ecology of the world's oceans, seas, and larger lakes.

On Nimbus-7, the Stratospheric Aerosol Measurement II (SAM-11) instrument continues to add to a twelve-year data set on atmospheric aerosols and stratospheric clouds in the Earth's polar regions. Data from the Total Ozone Mapping Spectrometer (TOMS) instrument on Nimbus-7 continue to provide accurate maps of total atmospheric ozone, as they have since launch in 1978. This instrument was joined in space by a TOMS instrument launched on the USSR Meteor-3 spacecraft in 1991.

Data from the Solar Backscatter Ultraviolet/2 (SBUV/2) instruments, on the NOM-9 and NOAA-11 satellites, provide column abundances and vertical profiles of atmospheric ozone beneath the orbital tracks of these satellites, continuing the collection of a data set begun with the SBW instrument on Nimbus-7 in 1978. A carefully calibrated version of the same instrument, called Shuttle SBW (SSBW), has been flown twice on the Space Shuttle and will continue to fly periodically in the early and middle 1990's. The SSBW provides correlative measurements so that TOMS and SBW instruments flying on other spacecraft can be more accurately calibrated, and provides information on the diurnal variability of stratospheric ozone in low latitudes.

On the Earth Radiation Budget Satellite (ERBS), data from the Stratospheric Aerosol and Gas Experiment II (SAGE-11) continue to provide vertical profiles of aerosols, ozone, and other trace gas species over Earth's tropical and mid-latitude regions, as they have since ERBS the launch in 1984.

The Earth Radiation Budget Experiment (ERBE) is comprised of three identical instrument packages flying on NOM-9, NOAA-10, and NASA's ERBS. These instruments continue to provide data illuminating the temporal and spatial variations in the Earth's radiation budget, which drive the Earth's climate, as they have since ERBS's launch in 1984. Data from the Earth Radiation Budget (ERB) instrument on Nimbus-7, and from the ERBE instruments, provide the only continuous data set on total solar irradiance (solar constant) and its temporal variations stretching from 1978 to the present.

NASA's Alaska Synthetic Aperture Radar Facility (ASF), based at the Geophysical Institute at the University of Alaska in Fairbanks, began acquisition and processing of SAR data transmitted from the European Space Agency spacecraft ERS-1 in early 1991. Data from the Japanese JERS-1 and the Canadian RadarSat spacecraft will also be acquired and processed after launch of these spacecraft. These data will provide important information on the properties and dynamics of sea ice and other land and ocean processes in the polar regions.

The Consortium for International Earth Science Information Network (CIESIN) serves as an affiliated data center for NASA's EOS program. It will facilitate the access to and use of Earth science data for global change research and public policy making. The CIESIN is currently analyzing existing and future Earth science information resources and current national and international plans for data integration, analysis and modeling.

The Administration is committed to the continued acquisition of Landsat-type data for national security, global change research, and other Federal users needs and is proposing in FY 1993 to initiate the procurement of a Landsat 6 follow-on. The DOD will be responsible for the procurement and launch of the spacecraft and the NASA will be responsible for acquisition and distribution.

CHANGES FROM FY 1992 BUDGET ESTIMATE

In FY 1992, Congress directed that the mission operations and data analysis program be increased by $25.0 million for the CIESIN program, and $2.5 million for Landsat activities.

BASIS OF FY 1993 ESTIMATE

Operations of the Nimbus-7 and ERBS spacecraft and processing and analysis of their data will continue, as will processing and analysis of data from NOM-based and Shuttle-based SBUV instruments. Processing and analysis of SAR data acquired at the ASF from ESA's ERS-1 will also continue and be augmented by similar processing and analysis of SAR data from Japan's JERS-1. Operations of the UARS and TOPEX spacecraft and processing and analysis of their data will begin in FY 1992 and continue into FY 1993. Processing and analysis of data from the TOMS instrument flying on the former USSR Meteor-3 spacecraft will begin in FY 1992. Processing and analysis of data from various NASA SAR instruments (including an airborne version) will continue, in preparation for flight of SIR-C in 1993. Funding for the Ocean Color Mission (OCM) will allow eventual purchase, processing, and analysis of ocean color data.

It is anticipated that NASA will develop and manage the ground segment (ground processing and mission operations systems) of the Landsat program as well as a Tracking and Data Relay Satellite (TDRS) communication antenna for the Landsat 7 satellite. The ground processing system will include satellite command, control, and telemetry. The data processing, product generation capability, and data archival. An early priority will be to preserve the existing Landsat 1-5 archive by transferring the data to a more stable medium. The NASA role is compatible and consistent with the work now in the Earth science and applications mission operations and data analysis program. The DOD will be responsible for the procurement and launch of the spacecraft.

BASIS OF FY 1993 FUNDING REQUIREMENT

INTERDISCIPLINARY RESEARCH AND ANALYSIS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Interdisciplinary research and analysis	12,400	2,500	2,500	2,600

OBJECTIVES AND STATUS

Interdisciplinary research activities are conducted to characterize quantitatively the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and the atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes. Such research is essential to investigating and assessing long-term physical, chemical, and biological trends and changes in the Earth's environment. Included in the program activities are joint efforts from a variety of disciplines, including atmospheric science, climatology, biological sciences, geochemistry, and oceanography.

BASIS OF FY 1993 ESTIMATE

In FY 1993, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of oceanic processes, atmospheric dynamics and radiation, upper atmosphere/troposphere chemistry, and land processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific pilot studies such as those understanding the biogeochemical processes controlling the concentration of atmospheric methane, characterizing changes in properties of the land surface and their effect on climate, and understanding the role of the oceans in the global carbon cycle.

BASIS OF FY 1993 FUNDING REQUIREMENT

MODELING AND DATA ANALYSIS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Physical climate and hydrologic systems modeling and data analysis. .	28,000	28,000	32,000	28,000
Biogeochemistry and geophysics modeling and data analysis	16,300	17,000	17,000	17,000
Total	44,300	45,000	49,000	45,000

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The research and analysis activities within the physical climate and hydrologic system program provide a focus for contributing to an improved understanding of the fully-integrated geophysical climate system, its interactions and predictability, through the development and multi-disciplinary exploitation of global satellite observations of the Earth, numerical modeling, climate impact assessments, and sensitivity studies. The two principal components of the program are in the areas of climate modeling research and climate data analysis.

The objectives of the climate modeling research program are to develop and improve global circulation models which assimilate and optimize the use of satellite-derived data sets for understanding climate interactions; to help guide the design of the global observing system, and to improve the capability for reliable climate diagnosis and forecasting. The program builds on the broad foundation established over the past decade of research on geophysical modeling conducted under the NASA atmospheric dynamics and radiation and ocean processes programs.

The objectives of the climate data analysis program are to assemble a long-term global record of climate parameters, with an emphasis on satellite remote sensing, for specifying and analyzing the state of the climate system and its variability. These include the full range of geophysical variables which describe the structure and composition of the atmosphere, oceans, land surfaces, and cryosphere, as well as their boundaries, interfaces, and external forcings. The program builds on earlier accomplishments achieved through such diverse research initiatives as the International Satellite Cloud Climatology Project (ISCCP), the Earth Radiation and Budget Experiment (ERBE), the Global Atmospheric Research Program (GARP) and current activities in support of the Tropical Oceans Global Atmosphere Program (TOGA) and the World Ocean Circulation Experiment (WOCE). These programs are elements of the World Climate Research Program (WCRP), sponsored by the World Meteorological Organization and the International Council of Scientific Unions. Such international relationships are strongly encouraged by the U.S. Global Change Research Program plan.

The biogeochemistry and geophysics modeling and data analysis has as its objectives the development of global change models dealing with all aspects of the biology, chemistry, geology, and geophysics of the Earth system, with the exploitation of satellite data in the monitoring of global change as well as the study of the mechanisms which are at work in the global environment. There are four major elements to the program: ocean biogeochemistry, atmospheric chemistry, geophysical modeling and analysis, and ecology and land atmosphere interactions.

In the ocean biogeochemistry program element, the emphasis is on data analysis efforts utilizing existing satellite data sets to understand better the variations in ocean productivity and preparing improved algorithms and data systems for the Ocean Color Mission.

The atmospheric chemistry program element is centered on the numerical modeling and analysis of measurements trace constituents in the troposphere-stratosphere system. Numerical models are used to test our understanding of atmospheric chemistry and of the way in which meteorological processes affect the trace constituent distribution in the atmosphere. Models are also used to predict future changes to the chemical composition of the atmosphere.

Research in geophysical modeling and analysis consists of modeling and analysis of the Earth's internal structure and dynamics through measurements of the gravitational and magnetic fields, Earth rotation and polar motion, and geodetic properties. The spatial variability of the potential fields and the temporal variability of the motion fields are the critical observational parameters.

In the ecology and land atmosphere interactions program element, global scale observations are analyzed to better understand the current state of terrestrial ecosystems, to assess their natural variability, and to determine the impacts of anthropogenic forcings. Numerical models and multi-temporal satellite observations are used to study sources and sinks of biogeochemical species and to investigate the interactions of climatic events such as El Nino with surface biology and atmospheric composition. Theoretical modeling of ecosystem functioning and land atmosphere interactions is conducted using global circulation models with explicit, interactive biospheres.

CHANGES FROM FY 1992 BUDGET ESTIMATE

In FY 1992, modeling and data analysis was increased by $4.0 million for increased climate modeling studies in accordance with Congressional direction.

BASIS OF FY 1993 ESTIMATE

The ocean biochemistry program element will increase the emphasis on modeling of the chemical interactions between the oceans, land and atmosphere. In atmospheric chemistry, emphasis on multi-dimensional modeling of the troposphere will be increased. The studies in ecology and land atmosphere interactions will place increased emphasis on ecosystem sources of key trace species in the atmosphere.

BASIS OF FY 1993 FUNDING REQUIREMENT

PROCESS STUDIES

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget
	(Thousands of Dollars)			
Radiation dynamics and hydrology	31,800	34,200	34,200	34,000
Ecosystem dynamics and biogeochemical cycles	20,600	23,300	23,300	23,100
Atmospheric chemistry	28,300	30,900	30,900	30,300
Solid earth science	26,800	25,900	25,900	30,200
Laser research facilities	8,700	9.000	9.300	9.000
Total	116.200	123,300	123,600	126.600

OBJECTIVES AND STATUS

The research and analysis activities within the radiation dynamics and hydrologic processes program combine a core effort of theoretical, laboratory, and field investigations essential to understanding the basic geophysical processes and their interactions which control climate. The two principal components of the program are in the areas of radiation and dynamic processes research and hydrologic processes research.

The objectives of the radiation and dynamics research program are to improve our understanding of the basic physical processes by which the atmospheric system transforms, stores and transports energy. Of all the exchange processes, radiation energy has a special role in climate because the energy balance of the climate system as a whole is determined by a balance between absorbed solar radiation and emitted thermal radiation. Understanding atmospheric dynamics is essential to understanding how the atmosphere behaves and its role in determining climate and climate change. Special emphasis is given to the processes responsible for cloud-radiation interaction and feedback. The first International Satellite Cloud Climatology Project (ISCCP) Regional Experiment (FIRE), which builds on the foundation established earlier under the NASA atmospheric dynamics and radiation research program, is a central focus for the program. The FIRE is an integrated research program whose objectives are: to expand our basic knowledge of cloud interactions with the environment and climate; to identify and simulate the physical and chemical processes involved in large-scale cloud systems; to quantify and improve current models for simulating large-scale cloud systems and the radiative properties of these systems; to improve cloudiness and radiation parameterizations used in global models; and to assess and improve the reliability of current cloud/radiation monitoring systems from space and from the ground.

The objectives of the hydrologic processes research program are to improve our understanding of the physical processes which govern the hydrological cycle and its impact on the atmosphere and oceans. The prediction of global change in the geosphere and biosphere will be one of the most important problems in environmental sciences in the twenty-first century. Estimation of the distribution and transport of carbon, nitrogen, sulfur, etc., cannot be obtained without knowledge of the atmospheric circulation and water cycle on regional and global scales. Knowledge of the distributions of water and its phase transformations, from vapor to liquid to solid, is paramount to understanding the energy sources and sinks which drive atmospheric and oceanic circulations. The availability of water is also a major factor affecting the distribution of the biomass and biological productivity. The biomass and land cover, in turn, play a role in controlling the absorption of solar radiation, evapotranspiration, and turbulent heat transfer.

The ecosystem dynamics and biogeochemical cycles program conducts research on the function of global ecosystems and the interactions of the Earth's biota with the atmosphere and hydrosphere. Particular emphasis is placed on understanding land atmosphere interactions and the carbon cycle. The two principal components of the program are the ecosystem dynamics program element and the biogeochemical processes program element.

The goal of the ecosystem dynamics program element is to achieve an improved understanding of the role of the biosphere and the biologically-linked components of the hydrologic cycle in processes of global significance. Specific objectives are to develop understanding of the ecological controls on the exchanges of energy, water, and nutrients between ecosystems and the atmosphere, the response of ecosystems to change, and the biophysics of remote sensing of ecosystem properties. Airborne and spaceborne remote sensing measurements and process models are used extensively to achieve these objectives and to extend or extrapolate small-scale process information to regional and global contexts.

The goal of the biogeochemical processes program element is to achieve an improved understanding of the sources, sinks, fluxes, trends, and interactions involving the biogeochemical constituents within the Earth system, with an emphasis on their major biospheric reservoirs, including oceanic and terrestrial systems. A major focus is on developing a better understanding of terrestrial and oceanic primary productivity and the fluxes of carbon within these ecosystems and between them and their biotic environment. Other important objectives are to identify the biological/ecological sources of radiatively and chemically active trace gases (current focus is on carbon dioxide, methane, and nitrous oxide) and to quantify their major exchanges between the Earth's biosphere and its atmosphere.

The atmospheric chemical processes program is composed of two elements: the upper atmospheric research program - (UARP) and the tropospheric chemistry program (TCP). The UARP is a large, comprehensive research program with NASA playing a leadership role as mandated by Congress under the Clean Air Act of 1976 and the FY 1976 NASA Authorization Act. The program aims at expanding our knowledge of the physical, chemical, and meteorological processes that control the concentration and distribution of atmospheric ozone, thereby providing the necessary input for large-scale global models used to predict the future state of stratospheric composition. The TCP is focussed on tropospheric chemical change, the natural and anthropogenic processes that cause it, and its effects on global climate and on the chemistry of the stratosphere through troposphere-stratosphere exchange.

One of the primary challenges in the study of the Earth as a system is understanding the extent and causes of atmospheric chemical changes and their consequences, including stratospheric ozone depletion and potential global climate change. Research activities include a wide range of field observations using satellites, balloons, aircraft, and ground-based measurement systems. The measurement projects are designed to study the troposphere and the stratosphere on a global scale. Thus, ecosystems ranging from tropical rain forest to Antarctica are encountered. The research covers a full range of altitudes, seasons, and solar energy input. The field experiments are complemented by laboratory studies in chemical kinetics, photochemistry, and spectroscopy.

The solid Earth science program conducts research in the fields of geology and geodynamics with the goal of improving our understanding of the evolution, structure, and dynamics of the Earth's interior and surface by testing hypotheses through a vigorous program of measurement and analysis of space-based geodetic, remote sensing, space-based geopotential, and related data. In geodynamics, emphasis is placed on understanding the rates and mechanisms of Earth's crustal deformation from local to global scale and how these reflect historical global change or influence current processes of global change. In geology, emphasis is placed on the interaction of the solid Earth with the hydrosphere, atmosphere and biosphere in programs under development and implementation in the early 1990's which address soil development and erosion, volcano-climate interaction, and coastal processes. The role of soil in the global carbon cycle is possibly the most poorly documented element of that cycle. Historical volcanic activity has been shown to have dramatic short-term (1-2 years) effects on atmospheric composition and it is important to understand the potential such activity has to affect long-term trends in global climate change. Coastal subsidence or emergence phenomena represent the integrated result of complex processes including local erosion or deposition, regional tectonic variation including post-glacial rebound, and global sea level change.

The objective of the laser research program is to measure the movement and deformation of the tectonic plates of the Earth. Laser ranging to satellites and the moon, microwave interferometry using astronomical radio sources and transmissions from the global positioning satellite system (GPS) are used to determine precise position locations.

CHANGES FROM FY 1992 BUDGET ESTIMATE

An additional $0.3 million has been applied to Laser Research Facilities from Airborne Science and Applications.

BASIS OF FY 1993 ESTIMATE

FY 1993 funding is required in the area of radiation and dynamics research to continue studies of the processes associated with cloud-radiation feedback, ocean circulation and heat flux. Emphasis for the ecosystem dynamics and biogeochemical processes program in FY 1993 will be on preparing for and conducting research to calibrate, validate, and verify data acquired from the Ocean Color Mission. The United States/Canada Boreal Ecosystem - Atmosphere Study (BOREAS), led by NASA, will conduct its first intensive field campaign in summer, 1993. This campaign will involve an international BOREAS science team in the collection of a broad range of satellite-, aircraft-, and surface-based measurements to study the interactions between the boreal forest biome and the atmosphere in order to clarify their roles in global change. Research and analysis studies will continue, focusing on studies of forest ecosystem dynamics, marine primary productivity, regional trace gas fluxes, and the biophysics of remote sensing. Analysis of the First ISLSCP Field Experiment (FIFE) data set, HAPEX-Sahel experiment data, and various multisensor airborne campaign data sets will continue. Both of the atmospheric chemical process programs will continue their activities to investigate and understand the global atmosphere through laboratory studies and field measurement campaigns. The solid Earth program will pursue its geodynamics research activities in large part through the Fiducial Laboratories for International Natural Science Network. The geodynamics program will continue to develop, in partnership with the European Space Agency (ESA), a geopotential research mission, ARISTOTELES, using gravity radiometry and magnetometers to study at high resolution the variability of Earth's gravity and magnetic fields.

BASIS OF FY 1993 FUNDING REQUIREMENT

AIRBORNE SCIENCE AND APPLICATIONS

	1991 Actual	1992 Budget Estimate	1992 Current	1993 Budget Estimate
		(Thousands of Dollars)		
Airborne science and applications	20,200	20,600	20,300	22,900

OBJECTIVES AND STATUS

The airborne science and applications effort requires operation of ER-2, C-130, and DC-8 aircraft in order to support Earth-sensing and atmospheric research. These aircraft support other major segments of the space science and applications program dealing with the Earth, the oceans, and the atmosphere. They may serve as test beds for newly developed instrumentation and allow demonstration of new sensor techniques before their flight on satellites or on Shuttle/Spacelab missions. Data obtained from these aircraft are used to refine analytical algorithms, and to develop ground data handling techniques. For example, the ER-2 acquires stratospheric air samples and conducts in situ measurements at altitude ranges above the capability of more conventional aircraft and below those of orbiting satellites. This capability is important in gaining an understanding of stratospheric transport mechanisms. The DC-8 carries a wide variety of instruments, ranging from a large complement of atmospheric sensors, to lidars and a three frequency synthetic aperture radar used in surface process studies.

Research facilities has been changed, with laser research facilities incorporated into process studies, and airborne sciences as its own category.

CHANGES FROM FY 1992 BUDGET ESTIMATE

$.3 million has been applied to the Laser Research (Process Studies) activities.

BASIS OF FY 1993 ESTIMATE

FY 1993 funding will allow operation of the DC-8, ER-2, and the C-130 aircraft. Operation of these aircraft will allow continuation of such projects as the collection and analysis of stratospheric air samples, testing of newly developed instrumentation, the demonstration of new sensor concepts, the investigation of the ozone hole phenomena, and participation in numerous other field experiments such as TOGA-CORE and continuation of the global tropospheric experiments.

MATERIALS
PROCESSING
IN SPACE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — MATERIALS PROCESSING IN SPACE

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and analysis	13,700	16,600	16,600	17,500	RD 7-3
Materials experiment operations	84,900	85,500	80,500	129,100	RD 7-4
Space Station utilization	--	21,300	19,300	48,700	RD 7-5
Commercial microgravity R&D enhancements	3,700	2,400	2,400	--	RD 7-6
Total	$02,300	125,800	118,800	195,300	

Distribution of Program Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	1,326	2,583	2,287	3,843
Marshall Space Flight Center	37,413	44,668	43,561	68,888
Lewis Research Center	31,057	41,963	39,483	66,336
Langley Research Center	2,333	4,982	3,513	5,903
Jet Propulsion Laboratory	22,890	28,276	19,779	33,232
Goddard Space Flight Center	80	85	110	185
Headquarters	7,201	3,243	10,067	16,913
Total	102,300	125,804	118,800	$95,300

OBJECTIVES AND JUSTIFICATION

The Materials Processing program uses the unique attributes of the space environment to conduct research in three primary areas: 1) Fundamental Science, which includes the study of the behavior of fluids and transport phenomena, condensed matter physics, and combustion science; 2) Materials Science, which includes electronic and photonic material, metals and alloys, glasses and ceramics; and 3) Biotechnology, which focuses on macromolecular crystal growth and cell science. Goals of the program include developing a comprehensive research program in these primary areas, to attain a more structured understanding of those physical phenomena made obscure by the effects of gravity. This understanding will provide the basis of a reliable predictive capability for processing operations and technology issues in both Earth and non-Earth environments. In FY 1993, ground-based research and payload development will support these program goals.

Ground-based research will support definition studies for flight experiment candidates in areas such as containerless processing, solidification and crystal growth, fluids and combustion research, and processing of biological materials. Ground based research includes drop-tubes, drop towers and aircraft.

The Materials Processing program provides a range of experimental capabilities. The program currently supports a wide variety of hardware development, from unique flight experiments necessary to conduct fundamental research to modular, multi-user research facilities that will be the cornerstone of microgravity science and applications research on Space Station Freedom (SSF). Experiments will be principally flown on the Shuttle, Spacelab, other commercially-developed spacecraft, and on the SSF.

BASIS OF FY 1993 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS (MATERIALS PROCESSING)

	1991 Actual	1992 Budget Estimate	1992 Current	1993 Budget Estimate
		(Thousands of Dollars)		
Research and analysis	13,700	16,600	16,600	17,500

OBJECTIVES AND STATUS

The research and analysis activity provides the scientific foundation for all current and future projects. Ground-based research leads to space investigations with potential for future applications. This activity also provides analytical support and technology development for future ground and space capabilities. Most research projects are initiated as a result of proposals from the scientific community which are extensively reviewed by peer groups prior to selection and funding.

BASIS OF FY 1993 ESTIMATE

Ground-based research and analysis will continue in FY 1993 in the areas of fundamental science, materials science, and biotechnology. Research will be conducted to define the role of gravity-driven influences in a variety of processes. A series of solicitations (NASA Research Announcements and Announcements of Opportunity), will be released to focus and expand the science community involvement. This will allow for the development of strong candidates for future flight opportunities.

BASIS OF FY 1993 FUNDING REQUIREMENT

MATERIALS EXPERIMENT OPERATIONS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Materials experiment operations	84,900	85,500	80,500	129,100

OBJECTIVES AND STATUS

The Materials Experiment Operations program provides experiments for a wide range of opportunities. NASA currently supports the development of Shuttle middeck, Spacelab and cargo-bay experiments. This policy maximizes the effective use of the Shuttle by developing hardware to meet experiment scientific and technical requirements. Preparations are underway to use the SSF as a major element for conducting microgravity research, consistent with the strategy for orderly evolution of microgravity experiments from ground-based research, to the Shuttle, and then to the SSF. During FY 1992 and FY 1993, hardware development and delivery of the first United States Microgravity Laboratory (USML-1) Spacelab mission, the first United States Microgravity Payload (USMP-1) mission and other Spacelab missions will continue. In addition, research and experiment flight hardware development will continue in the fundamental sciences, an important area in microgravity research.

CHANGES FROM FY 1992 BUDGET ESTIMATE

A Congressionally-directed reduction of $5.0 million has been applied across the program.

BASIS OF FY 1993 ESTIMATE

FY 1993 funds are required to continue basic and applied research activities as well as payload development for use in the STS middeck, Spacelab and cargo-bay for near-term flights such as USMP-2, and -3 as well as experiments to be flown on the next major mission after USML-1, the Spacelab USML-2 mission. Investigations are planned in electronic materials, metals and alloys, biotechnology, protein crystal growth, combustion, fluid physics and dynamics, glasses and ceramics.

FY 1993 starts Phase C/D development of both new and upgraded science instruments for flight on Spacelab USML-3 and USMP cargo bay missions, as well as new equipment for the Shuttle middeck. This new equipment will be used to carry out scientific investigations chosen from NASA Research Announcements in Combustion Science, Material Science, Biotechnology, Fluid Physics, and Fundamental Science. These investigations represent the future of the Microgravity Science and Applications program as the results of USML-1 and USMP-1 are disseminated and the program readies investigations for the Shuttle era.

BASIS OF FY 1993 FUNDING REQUIREMENT

SPACE STATION UTILIZATION

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Space station utilization.............	--	21,300	19,300	48,700

OBJECTIVES AND STATUS

The Office of Space Science and Applications is developing experimental modules and discipline facilities to perform flight experiments in the areas of materials science, biotechnology, and fundamental science. These experimental hardware systems are being developed to carry out flight experiments being selected through NASA Research Announcements and Announcements of Opportunity, and will utilize the SSF and other available carriers. The SSF utilization program includes the necessary planning and definition of payloads for the Space Science and Applications use of the SSF. Also, it involves definition of integration, operations, and training requirements and the development of Space Station and science support capabilities. Other options are being explored to address additional fundamental science questions and to offer opportunities to small and rapid response payloads.

CHANGES FROM FY 1992 BUDGET ESTIMATE

$2.0M has been reallocated to Commercial Use of Space to support the Commercial Middeck Augmentation Module (CMAM) program, reflecting its benefit to materials processing experiments.

BASIS OF FY 1993 ESTIMATE

FY 1993 starts full scale development of the Space Station Furnace Facility (SSFF) and continued development of the Advanced Protein Crystal Growth Facility (APCGF) for the SSF, a significant increase in effort and resources for both of these projects. This budget also supports early definition and design studies for the facilities and experiment modules for the disciplines of containerless processing, fluid physics, combustion science and biotechnology. New facilities are also being examined in the field of fundamental science, including cryogenic (low-temperature) research facilities. This year also starts effort to define the hardware changes required to transition flight hardware originally developed for Shuttle and/or Spacelab to the SSF for early utilization.

BASIS OF FY 1993 FUNDING REQUIRI

COMMERCIAL MICROGRAVITY R&D ENHANCEMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Commercial microgravity R&D enhancements	3,700	2,400	2,400	--

OBJECTIVES AND STATUS

The Commercial Microgravity R&D Enhancements budget supports several projects formerly managed by NASA's Office of Commercial Programs (OCP). The program funds the cost of modifying existing microgravity research hardware to accommodate members of the commercial user community and consolidates funding within the Office of Space Science and Applications (OSSA) for joint OSSA/OCP multiuser facilities. In 1992, the Crystal Growth Furnace is scheduled for flight on the USML-1 mission.

BASIS OF FY 1993 ESTIMATE

The commercial microgravity activity has been fully integrated into the FY 1993 Materials Experiment Operation budget.

COMMUNICATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — COMMUNICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
	(Thousands of Dollars)				
Advanced communications technology satellite	34,000	11,200	11,200	3,600	RD 8-2
Advanced communications research	11,400	15,300	(15,300)*	(16,500)	
Search and rescue	1,400	1,300	1,300	1,000	RD 8-3
Radio science and support studies	2,400	3,300	(5,000)*	(5,200)	
Communications data analysis	1.300	8.300	(6.600)*	(8.400)	
Total	50.500	39.400	12.500	4.600	

Distribution of Program Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Lewis Research Center	38,459	25,950	10,500	3,400
Goddard Space Flight Center	2,822	3,489	650	600
Jet Propulsion Laboratory	6,326	5,657	300	200
Johnson Space Center	25	--	--	--
Headquarters	2.868	4.304	1.050	400
Total	50.500	39.400	12.500	4.600

* Beginning in FY 1992, Advanced communications research activities have been transferred to Aeronautics and Space Technology. Radio science and support studies and Communications Data Analysis have been transferred to Commercial Use of Space.

BASIS OF FY 1993 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

	1991 Actual	1992 Budget	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Advanced communications technology satellite (ACTS)	34,000	11,200	11,200	3,600
STS operations	(4,900)	(34,700)	(9,600)	(29,400)
Upper stage	(18,500)	(5,800)	(13,300)	(7,400)

OBJECTIVES AND STATUS

The Advanced Communications Technology Satellite (ACTS) program is planned to maintain United States leadership in the communications satellite market by the development and flight verification of advanced technologies that will enhance the capability of communications satellites.

The United States user community, representing private sector organizations and other government agencies, will develop and execute experiments that will test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high effective isotropic radiated power; fast-hopping multiple beam antenna; on-board intermediate frequency and baseband switching; Ka-band components; and dynamic rain fade compensation techniques. The ACTS is planned for Space Transportation System/Transfer Orbit Stage (STS/TOS) launch in early 1993.

BASIS OF FY 1993 ESTIMATE

During FY 1993, final preparations for shipment of the spacecraft to the launch site will be initiated, proceeding to the launch and on-orbit checkout. The ground segment will be delivered, installed and tested at Lewis Research Center in preparation for on-orbit test and experiment operations. The ACTS experiments program will be conducted by the Office of Commercial Programs over the two-year design life of the spacecraft.

BASIS OF FY 1993 FUNDING REQUIREMENT

SEARCH AND RESCUE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Search and rescue	1,400	1,300	1,300	1,000

OBJECTIVES AND STATUS

The NASA role and budget for the international Search and Rescue program are limited to research and development that apply NASA technologies to advanced equipment design and techniques. The National Oceanic and Atmospheric Administration (NOM) has responsibility for all aspects of operational Search and Rescue, while the U. S. Coast Guard and the Air Force perform the rescues. The international Search and Rescue partners are Canada, France, former Soviet Union, Norway, United Kingdom, Bulgaria, Sweden, Denmark, Switzerland, Brazil, and India. The NASA budget contains no funding for Search and Rescue operations.

The Search and Rescue program, developed by NASA and international partners, has demonstrated the feasibility of using satellites to improve detection and location of general aviation aircraft and marine vessels during emergencies. As part of the post-development phase of the NASA Search and Rescue program, we are preparing for the application of NASA's skills to a wide range of public service endeavors.

BASIS OF FY 1993 ESTIMATE

Funding in FY 1993 will continue the NASA-unique research and development role in Search and Rescue, including the next generation satellite-borne Search and Rescue equipment, future system planning, and advanced technologies. As necessary, the FY 1993 budget will also support public service communications.

INFORMATION
SYSTEMS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

INFORMATION SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Information systems	35.700	42,000	35.000	40.700	RD 9-2

Distribution of Proeram Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Goddard Space Flight Center	19,360	21,439	17,629	20,097
Jet Propulsion Laboratory	4,114	5,440	3,158	5,829
Ames Research Center	6,447	6,200	7,624	8,058
Stennis Space Center	--	--	--	--
Marshall Space Flight Center	600	3,500	--	--
Headquarters	5.179	5.421	6.589	6,716
Total	35.700	42.000	35.000	40.700

OBJECTIVES AND STATUS

The Information Systems program is divided into four major discipline areas: scientific computing, science data management and archiving, science networking, and information systems research and analysis. In addition, the important function of conveying facts about NASA's information and data management systems is undertaken as part of program management responsibility. The Information Systems program provides advanced data systems to support the nation's space science and applications flight and research projects.

Science data management and archiving provides the research community with reliable systems to archive and distribute data. The National Space Science Data Center (NSSDC) archives and distributes data acquired from space flight investigations. Researchers benefit from automated retrieval of the archived data, a master directory for the location of distributed data sets by researchers, and delivery of data on advanced media as requested by users. Services now under development include catalog inter-operability for common searches across distributed data bases and utilization of data exchange standards to facilitate automated assimilation of data by user applications.

The main area of science networking is the NASA Science Internet. NASA Science Internet is a computer networking service developed for NASA's space science and applications community to enable NASA researchers worldwide to connect to databases, to computational resources, and also to other scientists for interactive collaboration. A main objective is to provide transparent and reliable networking connectivity to support OSSA's flight missions and discipline programs, including joint projects with other agencies and international organizations.

Information systems research and analysis emphasizes the application of advanced computer and information systems technology to improve the effectiveness and efficiency of science data management, analysis, and visualization. The NASA Center for Computations Science (NCCS) supercomputer continues an upgrade program to a capability of nearly 10 times the power of the current equipment. The science data management discipline began to process the data returning from missions launched recently. The NASA master directory is now completed and fully operational.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The reduction from the FY 1992 budget estimate of $7.0 million is due to a Congressional reduction of $5.0 million, and a $2.0 million transfer to the Global Geospace Science program.

BASIS OF FY 1993 ESTIMATE

The Information Systems program will increase emphasis on the application of computer science technologies to support the work of the NASA science disciplines. Funding is included for continued operation of the NCCS and NSSDC. The Information Systems program will continue to develop common software to support ongoing research in the space and Earth sciences. Science data networking needs will be improved with the NASA Science Internet upgrades, allowing more users access to the network consistent with the recently-launched and near-term science investigations. The 1992 initiated data management initiative will continue, with the objective of revitalizing science data holdings and establishing mechanisms for the systematic flow of science data into discipline-oriented archives.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — RESEARCH OPERATIONS SUPPORT

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Research operations support	(92,355)	(112,173)	82,300	98,000

OBJECTIVES AND STATUS

Research and operations support funding provides vital support to the civil service workforce and to the physical plant at the Centers and at NASA Headquarters. Support to the civil service workforce includes provision of the basic tools to work productively such as telephone and mail service, office supplies, equipment and furniture; and the basic photo, printing, and graphics shops. Support to the workforce also includes funding the support contractors, and supplies and equipment necessary to provide personnel, payroll, medical, and other administrative services. Support to the physical plant includes payment for center utilities, rental of buildings and space, and necessary fire protection, janitorial, and security services. Support to the physical plant also includes maintenance of roads and grounds, and general purpose facilities such as administrative buildings and the extensive utilities systems.

CHANGE FROM FY 1992 BUDGET ESTIMATE

In FY 1992 and previously, these activities were funded in the Research and Program Management/Operation of Installation appropriation. FY 1992 Congressional action both sharply reduced the requested funding for these activities, and authorized their transfer into the Research and Development and Space Flight, Control and Data Communications appropriations. This transfer has allowed the reduction to be accommodated with minimum impact by allowing the programs to fund some of the activities that had previously been covered by these funds.

BASIS OF FY 1993 ESTIMATE

NASA is in the process of deciding exactly how the activities previously budgeted in the Operations of Installation appropriation will be budgeted in future years. The FY 1993 estimate represents the amount required to provide the basic minimum institutional support, and it will be necessary to develop mechanisms that either allow this estimate to be supplemented by program funds or that incorporates some of the funding for these activities in the program budgets.

COMMERCIAL
PROGRAMS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Technology utilization	24,400	32,000	32,500	31,700	RD 10-1
Commercial use of space	63.600	118.000	116.100	139.900	RD 11-1
Total	88.000	150.000	148.600	$71.600	

TECHNOLOGY
UTILIZATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS — TECHNOLOGY UTILIZATION

SUMMARY OF RESOURCES REMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Civil systems	9,000	11,000	13,000	6,500	RD 10-4
Technology dissemination	6,600	8,000	8,700	11,700	RD 10-4
Technology evaluation and applications	8.800	13.000	10.800	13.500	RD 10-4
Total	24.400	32.000	32.500	31.700	

Distribution of Program Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	4,290	2,550	3,955	2,380
Kennedy Space Center	482	477	413	425
Marshall Space Flight Center	387	497	930	877
Stennis Space Center	546	645	750	570
Goddard Space Flight Center	900	1,016	1,252	1,460
Jet Propulsion Laboratory	466	491	625	600
Ames Research Center	555	517	710	412
Langley Research Center	733	789	960	620
Lewis Research Center	520	598	775	716
Headquarters	15.521	24.420	22.130	23.640
Total	24.400	32.000	32.500	31.700

OFFICE OF COMMER(, PROGRAMS TECHNOLOGY UTILIZATION

OBJECTIVES AND JUSTIFICATION

The NASA Technology Utilization program is designed to strengthen the national economy and industrial productivity through the transfer and application of aerospace technology resulting from NASA's R&D programs. To accomplish this objective, NASA operates a number of technology transfer mechanisms to make useful new technologies available to the private and public sectors of the economy. Almost every part of U.S. industry can benefit from the technology transfer process, especially in such areas as automation, electronics, materials, and productivity. In the public sector, medicine, rehabilitation, transportation and safety are areas in which aerospace technologies have been especially beneficial. The specific objectives of the program are:

- To accelerate and facilitate the application of new technology into the commercial sector, thus shortening the time between the generation of advanced aeronautics and space technologies and their effective use in the economy;

- To encourage multiple secondary uses of NASA technology in industry, education, and government, where a wide spectrum of technological problems and needs exist;

- To develop applications of NASA's aerospace technology, including its unique facilities, to address priority non-aerospace needs of the nation.

OBJECTIVES AND STATUS

The Technology Utilization (TU) program promotes the transfer of technology developed in NASA's R&D programs to the public and private sectors of the U.S. economy. A network of Regional Technology Transfer Centers and NASA installation technology utilization offices forms the core of the Agency's technology transfer efforts. Technologies developed for the Nation's aerospace program are reused or reengineered to provide new products and processes in the areas of transportation, energy, medicine, public safety, and consumer goods. The goal of the program is to broaden and accelerate the technology transfer process to increase dividends from national investments in aerospace research. This will also help the United States maintain its competitive position in the international marketplace.

Activities in FY 1992 include:

- Completing the restructure of the Industrial Applications Center network. Six Regional Technology Transfer Centers (RTTCs) have been competitively selected and will be fully operational.

- Improving the technology transfer capabilities of the Technology Utilization offices at the NASA field Centers. The Technology Utilization Network System (TUNS) will link together the NASA field Center TU offices, the NASA Software Repository, the Computer Software Management and Information Center (COSMIC), the Center for Aerospace Information (CASI) (formerly named the Scientific and Technical Information Facility), and the RTTCs to expedite distribution of new technologies.

- Promoting awareness of NASA's Technology Utilization program and resources available to the public and private sectors through a broad array of program materials, seminars and conferences. Technology 2001 attracted 4,000 participants and 183 exhibitors.

- Maintaining the nationwide technology transfer network to support cooperative efforts with the Federal Laboratory Consortium, state-sponsored business and technical assistance center, and Small Business Development Centers. These linkages enable the Technology Utilization program to keep pace with growing industrial demand for information and technology transfer services.

- Continuing operational upgrades of the AdaNET program, which transfers existing and emerging Ada software and other software engineering technology from the federal government to the private sector through mechanisms such as information sharing and repository services and networks. NASA, the Department of Defense, and the Department of Commerce are participating in this program.

- Continuing implementation of the National Technology Transfer Center (NTTC) at Wheeling Jesuit College.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The Civil Systems program, which includes the AdaNET and NTTC, remains unchanged. The funding for AdaNET has increased from $2.0 million to $4.0 million consistent with Congressional direction. Technology Dissemination has increased due to the recategorization of TUNS and CASI activities from Technology Evaluation and Applications, but this increase has been offset by the allocation of $1.5 million to Commercial Use of Space for the Commercial Middeck Augmentation Module. Technology Evaluation and Applications funding has decreased due to the recategorization of activities as described above.

BASIS OF FY 1993 ESTIMATE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Civil systems	9,000	11,000	13,000	6,500

In FY 1993, essential AdaNET development and operations activities will continue. This project is developing a national facility for acquisition and dissemination of government-generated software components for reuse by industry and government agencies. NASA, the Department of Defense, and the Department of Commerce are participating in this program.

The NTTC will be a national focal point to aid U.S. industry in locating appropriate Federal technologies and using their technology transfer services to accelerate the flow of advanced technological resources into new applications. The NTTC development processes are planned to continue over the next three years, and will become fully integrated with existing technology transfer mechanisms and sources of useful technology resulting from federally-sponsored R&D programs.

Technology dissemination	6,600	8,000	8,700	11,700

Technology dissemination activities will focus on expanding of the RTTC network's capabilities to respond to increasing demands for technology transfer products and services. The responsiveness of the information delivery process will be increased by broadening the geographical coverage of the network and by improving coordination with the technology transfer efforts of federal, state, local government agencies. The RTTC contract awards were announced in October 1991, and the contracts were initiated on January 1, 1992.

Technology evaluation and applications	8,800	13,000	10,800	13,500

The requested funding will support critical core technology utilization programs including technology identification activities and application engineering projects at all NASA field installations, technology evaluation, product development, and technology publications.

Funding will continue for an array of technology applications engineering projects in the areas of bioengineering and medicine, rehabilitation, manufacturing, materials and electronics. Additionally, the Technology Applications program will be revised and strengthened in FY 1993 to increase the effectiveness of technology development. Funding will be increase for applications of aerospace technology and products to three areas of national importance - law enforcement, education, and the environment.

Long range plans for NASA Technology Utilization will focus on assessing potential participants in U.S. industry, preparing information guidelines to support cooperative relationships throughout the NASA technology transfer network, and satisfying the increasing demand for TU publications and information.

COMMERCIAL
USE OF SPACE

RESEARCH AND DEVELOPMENT

FISCAL, YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS

COMMERCIAL USE OF SPACE

SUMMARY OF RESOURCES REOUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budeet Estimate	Page Number
		(Thousands of Dollars)			
Commercial applications and enhancements	33,600	40,800	40,300	44,100	RD 11-6
Commercial development support	3,800	6,700	5,100	5,300	RD 11-7
Commercial transportation	24,200	70,500	59,100	76,900	RD 11-7
Communications systems	2.000	(11.600)	11.600	13.600	RD 11-8
Total	63.600	118.000	116.100	139.900	

Distribution of Proeram Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budeet Estimate
Johnson Space Center	10,550	47,910	40,200	53,150
Kennedy Space Center	600	1,090	1,000	1,550
Marshall Space Flight Center	950	1,410	1,200	1,850
Stennis Space Center	4,650	5,600	4,750	5,100
Goddard Space Flight Center	1,200	1,400	1,500	1,450
Ames Research Center	450	550	600	700
Langley Research Center	350	250	300	700
Lewis Research Center.................	1,270	190	4,791	6,390
Jet Propulsion Laboratory	--	--	1,941	1,741
Headquarters	43.580	59.600	59.818	67,269
Total	63.600	118.000	116.100	139.900

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

OFFICE OF COMMERCIAL PROGRAMS **COMMERCIAL USE OF SPACE**

OBJECTIVES AND JUSTIFICATION

The goal of the Commercial Use of Space program is to support a national focus that develops opportunities for the expansion of U.S. private sector investment and involvement in civil space activities. The specific objectives of the program are to:

- Foster close working relations with the private sector and academia to encourage investment in space technology and the use of the in situ attributes of space-vacuum, microgravity, temperature and radiation, for commercial purposes.

- Facilitate private sector space activities through improved access to available NASA capabilities and the development of new high technology space markets.

- Encourage increased private sector investment in the commercial use of space independent of NASA funding.

- Implement and support commercial space policy NASA-wide.

NASA's goal of expanding opportunities for U.S. private sector investment and involvement in civil space and space-related activities is pursued through a variety of interrelated programs. Through cooperative agreements such as Joint Endeavor Agreements (JEAs) and through support to the Centers for the Commercial Development of Space (CCDS), NASA will increase the amount of space-related research conducted by the private sector, the number and type of NASA and private sector facilities available for space use, and the private sector awareness of opportunities to use NASA's terrestrial and space-based facilities for commercial research.

The CCDSs, a network of universities and private sector commercial enterprises, are the primary mechanisms that the CUS uses to achieve its space commercialization objectives. Seventeen CCDS will conduct applied research in fields with promising commercialization prospects, including the fields of space propulsion, biotechnology, materials processing, space remote sensing, and communications. The CCDSs are:

1. Space Automation and Robotics Center, located at the Environmental Research Institute of Michigan, in Ann Arbor, MI. (Focus: developing key space industrialization enabling technologies; developing commercial and technical plans, demonstrations and key components for space servicing applications; and providing support for terrestrial robotics and automation applications).

2. Wisconsin Center for Space Automation and Robotics, located at the University of Wisconsin. (Focus: to conceive, demonstrate and stimulate space and terrestrial commercialization of technology developed for astrobotics, astroculture, and astrofuel).

3. Center for Mapping, located at Ohio State University. (Focus: to develop and integrate different capabilities into commercial opportunities for the suppliers of both space remote sensing systems and information systems.)

4. Space Remote Sensing Center, a Division of the Institute for Technology Development, located at the John Stennis Space Center, MS. (Focus: providing commercial technology applications development of satellite remote sensing, image processing, and geographic information systems.)

5. BioServe Space Technologies, located at the University of Colorado at Boulder. (Focus: developing technologies in the areas of biomedical isomorphisms, controlled ecological life support systems, bioprocessing and bioproduct research, and related hardware development tasks.)

6. Center for Cell Research, located at Pennsylvania State University. (Focus: physiological testing, bioseparations and bioprocessing, and equipment and environment design.)

7. Center for Macromolecular Crystallography, located at the University of Alabama at Birmingham. (Focus: space-grown crystals of biological materials, and developing technology and applications for the space-based material processing of biological crystals.)

8. Advanced Materials Center, located at Battelle in Columbus, OH. (Focus: multi-phase matarials processing research in four technical areas: catalysts; metals and ceramics; polymers; and telectronic and optical materials.)

9. Center for Commercial Crystal Growth in Space, located at Clarkson University, (Focus: developing commercial crystal growth in space and developing a broad spectrum of crystal growth techniques (melt, solution and vapor, theoretical modelling, complementary thermophysical property measurement, and structural and electronic characterization.)

10. Consortium for Materials Development in Space, located at the University of Alabama in Huntsville. (Focus: developing commercial materials that benefit from unique attributes of space, and focus on commercial materials, commercial applications of physical chemistry and material transport, and prompt and frequent experiments and operations in orbit.)

11. Space Vacuum Epitaxy Center, located at the University of Houston, TX. (Focus: exploring R&D and commercial possibilities of thin film growth and materials purification in space.)

12. Center for Space Power, located at the Texas A&M University. (Focus: conducting research relevant to space power on developing and demonstrating technology associated with the commercial use of space.)

13. Center for the Commercial Development of Space Power and Advanced Electronics, located at Auburn University, AL. (Focus: identify critical technological impediments to the economic deployment of power systems in space, advance these technologies, and develop new products to meet the power generation, storage, conditioning, and distribution needs.)

14. Center for Space Transportation and Applied Research, located at the Tennessee Space Institute in Tullahoma, TN. (Focus: to stimulate research in and contribute to those propulsion technologies that are considered prime in achieving basic space flight mission objectives.)

15. Center for Materials for Space Structures located at Case Western Reserve University in Cleveland, OH. (Focus: to provide materials for space structures that are capable of being processed in space and capable of withstanding the space environment, such as polymeric composites, metallic composites, ceramic composites, organic coatings, and metallic coatings.)

16. Center for Satellite and Hybrid Communication Networks located at the University of Maryland at College Park, MD. (Focus: space-based communications especially in the context of hybrid networks which integrate terrestrial and extra-terrestrial communications technologies.)

17. Center for Space Communicaitons Technology, located at Florida Atlantic University in Boca Raton, FL. (Focus: to develop the commercial use of digital transmission techniques for transmitting video, audio and data to the Earth by satellite.)

The CUS program also continues to manage a commercial remote sensing program through the Stennis Space Center.

Resources are used to obtain flight support experimentation hardware required by industrial researchers associated with NASA-sponsored programs. This may include use of Shuttle middeck lockers, across-the-bay carriers, and middeck augmentation racks or their derivatives. Also, the hardware developed will be leased to the private sector to exploit commercial research and development in space. The use of ground-based research facilities, aircraft and commercial sounding rockets and commercial Expendable Launch Vehicles (ELV's) will be emphasized in order to provide limited access to the microgravity environment for appropriate commercial experiments.

The Commercial Middeck Augmentation Module (CMAM) contract, awarded to Spacehab, Inc., through open competition, involves flight accommodations and associated supporting services. This includes use of the commercially developed CMAM flight modules and trainers, physical and analytical integration services, training of flight crews, and support to experiment flight operations. The CMAM flight modules are pressurized, orbiter-based, mixed cargo carriers designed to augment the orbiter middeck by providing approximately 1100 cubic feet of additional volume for support of crew and payloads. Fifty middeck locker volume equivalents (MLVEs) of payload space can be accommodated on each module. CMAM is connected to the orbiter through a modified Spacelab tunnel adapter and draws resources from the orbiter cabin and cargo bay payload support provisions. Cooling, power, command/data and housekeeping systems (lighting, fire suppression, atmosphere control, status monitoring, and crew emergency breathing) are provided. The CMAM is being procured under a lease-tenant arrangement. The first CMAM flight is scheduled for early 1993, and will accommodate 14 CCDS payloads/experiments.

The Commerical Experiment Transporter (COMET) is a fully integrated space transportation and recovery service to meet the needs of the United States' research and development community. This service, with three launches planned for the 1992-1995 time frame, will carry experiments to the microgravity of space and return, providing basic utilities such as electric power, controlled temperature, orientation, data management, and communications while in orbit. The COMET provides flexible payload accommodations for a wide variety of materials and equipment. Each mission will launch a two-part free flyer which will carry experiements into a nominal 300 nautical mile orbit, consisting of a service module and a recovery system which returns to land by parachute after 30 days in orbit. Access the payloads in the recovery system is possible up to six hours before launch for installation of degradable or limited life materials.

The COMET program was established and is being implemented by the Center for Space Transportation and Applied Research (CSTAR) located at the University of Tennessee Space Institute in Tullahoma, Tennessee. The first launch is scheduled for September 1992.

In order to maintain momentum in Commercial Use of Space activities and to encourage an increase in private sector investment in space, NASA will continue to develop methods to facilitate private sector agreements and commitments to pursue commercial opportunities in space. The development of agreements for the use of the Shuttle external tanks and private sector use of U.S. launch facilities reflect this effort.

The Advanced Communications Technology Satellite (ACTS) program will help the U.S. maintain its leadership in the communications satellite market by the development and flight verification of advanced technologies that will enhance the capability of communications satellites. The U.S. user community, representing private sector organizations and other government agencies, will develop and execute experiments that will test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high effective isotropic radiated power; fast-hopping multiple beam antenna; on-board intermediate frequency and baseband switching; Ka-band components; and dynamic rain fade compensation techniques. The ACTS is planned for a Space Transportation System/Transfer Orbit Stage (STS/TOS) launch in 1993.

The Radio Science, Communications Satellite Commercialization program provides technical support for U.S. and NASA interests in international and domestic communications regulatory forums. For example, propagation in the measurements are performed in order to understand and account for the effects of signal propagation in the design and specification of space communications systems. Studies to enable new satellite applications are conducted.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The Commercial Use of Space (CUS) budget is reduced by a net $1.9 million because of several changes. The Communications Systems activities previously budgeted under Space Science and Applications ($11.6 million) have been transferred to CUS consistent with actions approved in FY 1991. There is no significant change in the nature of these activities.

A Congressional budget reduction of $26.0 million to CUS has required reallocation of funds in order to support the minimum funding requirements for the Commercial Middeck Augmentation Module *(CMAM)* program. Funds have been reallocated from Space Transportation Capability Development, Life Sciences, Space Applications, Technology Utilization, and from other CUS budget elements in order to continue the program on a renegotiated payment schedule with Spacehab, Inc. This will ensure the provision of required flight opportunities for commercial payloads currently under development. The CMAM will be funded at $39.0 million, with an initial flight scheduled for April 1993.

BASIS OF FY 1993 ESTIMATE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Commercial applications and enhancements	33,600	40,800	40,300	44,100

The Commercial Use of Space program will use FY 1993 resources to manage the process of designing and preparing CCDS experiments and payloads for flight on the shuttle and on other transportation systems. Continued development of space-oriented, ground-based facilities, equipment, and expertise will promote private sector decisions to commit to space research and production. In collaboration with the Department of Defense, other civilian agencies, academia, state and local governments, and the private sector, the Commercial Use of Space program will participate in developing coordinated policies and guidance for commercial microgravity research and development. The Commercial Use of Space program will also promote the use of applicable NASA capabilities by the private sector.

FY 1993 funding is provided for the analytical and physical integration required for Space Shuttle payloads flown by the CCDSs and under commercial cooperative agreements and Joint Endeavor Agreements (JEAs). Direct funding is provided to perform Space Shuttle optional services, for which reimbursement is deferred under some Space Systems Development Agreement (SSDAs). NASA's current SSDAs are with Spacehab, Inc., and Space Industries Partnership.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Commercial development support	3,800	6,700	5,100	5,300

The rapidly changing nature of the commercial space industry requires that Commercial Use of Space program activities anticipate and respond to the commercialization needs of the industries it supports. FY 1993 resources included under Commercial Development Support will provide the services necessary to support these objectives. Resources will be used to provide strategic planning services, space industry trend analysis, market analysis, ADP services, and general administrative support.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Commercial transportation	24,200	70,500	59,100	76,900
Commercial middeck augmentation module	(9,200)	(46,000)	(39,000)	(51,400)
Commercial experiment transporter ...	(10,500)	(20,000)	(18,000)	(22,000)
Sounding rockets	(4,500)	(4,500)	(2,100)	(3,500)

Over 40 commercial payloads are scheduled for flight during FY 1993, continuing the expansion in the flight rate that begins in FY 1992. The CUS program will meet increased flight requirements with a well-balanced transportation program. In addition to Shuttle payloads, the commercial transportation program components will consist of the following: (1) Commercial Middeck Augmentation Module (CMAM), supporting middeck-class experiments that require crew support, pressurization, late access and early retrieval, and ascent/descent power; (2) the Commercial Experiment Transporter (COMET) project, an expendable launch vehicle system providing launch, low-earth orbit operations, payload recovery, and long-duration microgravity; and, (3) sounding rockets, supporting short-duration microgravity requirements for payloads that are preparing for orbital flights or other follow-on work.

CMAM project resources will support the flight schedule profiles which are scheduled for renegotiation with Spacehab, Inc. during FY 1992. The first CMAM flight is scheduled for April 1993. The contract to develop the COMET system and services was signed during the second quarter of FY 1991, and the FY 1993 request provides follow-on funding for the project. The first of three COMET launches scheduled under the contract is on schedule for launch in the fall of 1992. The FY 1993 request provides funding to continue the sounding rocket program at a minimum of one flight per year.

COMMUNICATIONS SYSTEMS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Advanced communications technology....	1,924	(6,600)	6,600	8,400

During FY 1993, proposals for experiments will be solicited and evaluated and plans will be prepared for the use of the ACTS satellite when it is operational. In addition, two new Centers for the Commercial Development of Space will be funded.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Radio science, communications satellite commercialization	76	(5,000)	5,000	5,200

Studies will continue to examine more efficient use of the radio frequency spectrum and geostationary satellite orbit. Funding will support development of the technical basis for standards development and regulatory decisions for space services at the national and international levels. Propagation studies and measurements will be carried out to fill the voids in data needed for design of new satellite applications for fixed communications, mobile communications, and audio broadcasting. Studies will be performed to identify new satellite applications.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY FOR AERONAUTICS AND SPACE RESEARCH AND TECHNOLOGY

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Aeronautics research and technology ...	512,000	591,200	774,600	890,200	RD 12-1
Transatmospheric research and technology	95,000	72,000	20,000	80,000	RD 13-1
Space research and technology	286.888	421.800	309.000	332.000	RD 14-1
Total	893.888	1.085.000	1,103,600	1.302.200	

AERONAUTICAL
RESEARCH
AND TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY

Y OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base.	336,400	375,600	360,700	394,000	RD 12-4
Systems technology programs	175,600	215,600	203,800	253,000	RD 12-12
Research operations support	(235,310)*	(281,812)*	210,100	243,200	RD 12-29
Total	512.000	591,200	174.600	890.200	

* Previously funded in the Research and Program Management (R&PM) appropriation.

Distribution of Proeram Amount Bv Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Marshall Space Flight Center	220	--	--	--
Jet Propulsion Laboratory	982	700	2,000	2,500
Goddard Space Flight Center.	721	500	3,900	7,400
Ames Research Center.....	195,129	199,500	262,300	299,200
Langley Research Center	176,285	206,600	232,400	260,400
Lewis Research Center....	126,926	170,500	213,700	257,100
Headquarters	11,737	13,400	60,300	63,600
Total	512.000	591.200	774.600	890.200

512

336
175
512

376
216
592

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY | **AERONAUTICAL RESEARCH AND TECHNOLOGY**

OBJECTIVES AND JUSTIFICATION

The goal of the NASA program is to conduct aeronautical research and develop technology to strengthen U.S. leadership in civil and military aviation. The program is based on a strong commitment to develop a broad technology base in support of the aviation industry, enhance the safety and capacity of the national airspace system, and assure U.S. superiority for national security. With the U.S. challenged as never before in aeronautics, the FY 1993 estimate reflects the need to address critical barriers and strengthen technology development in selected high payoff areas that are vital to our long-term leadership in aviation. NASA's aeronautics program is focused on six strategic thrusts: (1) develop selected, high-leverage technologies and explore new means to ensure competitiveness of U.S. subsonic aircraft and to enhance the safety and productivity of the national aviation system; (2) resolve the critical environmental issues and establish the technology foundation for economical, high-speed air transportation; (3) ready technology options for revolutionary new capabilities in future high-performance aircraft; (4) develop measurement and instrumentation technologies to support ground and flight demonstration of the X-30 National Aero-Space Plane and critical technologies to support the development of other future hypersonic vehicles; (5) pioneer the development of innovative concepts, and provide the physical understanding and the theoretical, experimental, and computational tools required for the efficient design and operation of advanced aerospace systems; and (6) develop, maintain and operate critical national facilities for aeronautical research and for support of industry, Department of Defense (DOD) and other NASA programs. In accomplishing these thrusts, the program will maintain NASA laboratory strength, including enhanced experimental and computational capabilities and staff excellence; ensure timely domestic technology transfer; ensure strong university involvement; and ensure strong support for and cooperation with the DOD, Federal Aviation Administration, and industry partners. Beginning in FY 1992, support to the civil service workforce and center support systems, which was previously funded in the Research and Program Management (R&PM) appropriation, will be funded as Research Operations Support.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The net increase of $183.4 million is the result of a reduction of $26.7 million in the Aeronautics Research and Technology program which reflects a general reduction of $17.0 million directed by Congress and a reallocation of $9.7 million to Transatmospheric research and technology and an increase of $210.1 million for the transfer of Research Operations Support which was previously funded as Operation of Installation in the R&PM appropriation. The Aeronautics Research and Technology programs have been impacted as described in the statements which follow.

BASIS OF FY 1993 ESTIMATE

The FY 1993 research and technology program is committed to providing a strong fundamental foundation for future advances as well as addressing the critical issues associated with the U.S. air transportation system; to enhancing American competitiveness and product superiority in the international marketplace; and to increasing the margin of the country's pre-eminence in aviation for national security. Technologies are being pursued which offer major advances in vehicle performance and capabilities, and which provide substantial positive impact on U.S. competitiveness. Major research efforts are underway in high-payoff areas associated with a broad range of future vehicle applications including subsonic and high-speed transport aircraft. The demands for NASA's unique wind tunnels continue to increase with the emergence of civil and military aircraft development and modification programs. In order to ensure wind tunnel availability to meet these demands, a major revitalization program was initiated to modernize NASA's major wind tunnels for productive use well into the next century. This revitalization program is entering its fifth year in FY 1993.

BASIS OF FY 1993 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Aerodynamics research and technology ..	116,481	128,300	126,100	140,100
Propulsion and power research and technology	71,663	84,100	80,000	83,900
Materials and structures research and technology	37,210	42,800	38,400	40,600
Controls, guidance and human factors research and technology	60,292	67,600	63,300	73,500
Flight systems research and technology	40,454	42,100	43,100	45,500
Systems analysis	10.300	10.700	9.800	10.400
Total	336,400	375.600	360.700	394.000

OBJECTIVES AND STATUS

The overall objective of the research and technology base program is to provide a strong fundamental foundation for future aviation advances. Major emphasis is on fundamental understanding of a broad range of physical phenomena, development of computational methods to analyze and predict the physical phenomena, and appropriate experimental validation. These efforts ultimately lead to design and analysis tools with application to each of the six aeronautical strategic thrusts.

Aerodvnamics research and technology explores a wide range of fluid flow phenomena from basic fluid mechanisms to applied aerodynamics. Validated aerodynamics technology is developed through theoretical, computational and experimental efforts which are applicable to civil and military aircraft across all speed ranges. The advanced computational methods developed by this research are used for more accurate and efficient prediction of aircraft aerodynamic performance, as well as for exploration of fluid physics phenomena. These fluid mechanics research efforts in FY 1992 are producing an improved understanding of flow transition mechanisms and turbulence dynamics, increased simulation and modeling capability, and provided the basis for new flow control concepts. Computational methods research also emphasizes the development and validation of advanced analytical tools, including improved methods for configuration surface modeling and grid generation. Experimental techniques research includes advanced sensor development for wind tunnel and flight testing. Nonintrusive global measurement techniques are being pursued to reduce the time required for accurate flowfield surveys and computational method validation. Luminescent paint for wind tunnel models is a revolutionary technique developed to provide real-time sensing of pressures over entire model surfaces. The use of heavy gases for wind tunnel testing media is being investigated to achieve high Reynolds numbers at low dynamic pressures for accurate high-lift experimentation. In the subsonic regime, flight and wind tunnel testing, as well as computational studies, were performed to improve aerodynamic efficiency and reduce noise. In FY 1992, the analysis of flight test results will be completed on hybrid laminar flow control applied to a Boeing 757 aircraft to reduce drag. High-lift flap technology was advanced with additional flight data taken on the B-737 airplane. Vortical flow analyses and flight control methods were developed to provide improved handling qualities of high-performance aircraft at high angles-of-attack. Rotor research activities included initial flight airloads testing for acoustics and loads prediction. Advanced rotor and low noise airfoils were tested in the 40x80-foot wind tunnel. Generic hypersonics research focused on experimentation to support the development of turbulence models which account for compressibility. Computational aerodynamics methods are being developed for slender bodies and highly swept wings that are characteristic of supersonic cruise configurations.

The propulsion and power research and technology program provides the understanding of the governing physical phenomena occurring at the disciplinary, component and subsystem levels that will provide the basis for improved propulsion systems. Ongoing disciplinary research in instrumentation, controls and internal fluid mechanics is providing the foundation necessary for continued advancement at the component and subsystem level. Component and subsystems research is being conducted for a wide variety of applications, including subsonic transports, high-performance aircraft, supersonic cruise and hypersonic vehicles. Experimental measurements of the large, low-speed centrifugal compressor were initiated in FY 1991 to develop a complete code validation data base using nonintrusive detailed measurements of the flowfield. The data base will be completed in FY 1992 and used to validate existing codes and improve advanced codes currently under development. In FY 1991, experimental tests of improved rotary-engine rotor, exhaust port and fuel injector designs demonstrated the potential to attain 0.35 horsepower/pound/hour, the program goal in brake specific fuel consumption. Final documentation of the test results to date and evaluation of the potential for further technology development will be completed in FY 1992. Laboratory experiments demonstrated thin film surface temperature and heat flux sensors capable of operating at 2500' to 3000' Fahrenheit for use with high-temperature uncooled ceramics in gas turbine hot sections. In hypersonics propulsion research, experiments were performed using a small-scale multimode scramjet engine in an open-loop control mode to determine low-speed operating characteristics, inlet start and unstart characteristics, and the effects of changing fuel-to-air ratio on engine stability. A fiber optic speed sensor was tested on an F-15 aircraft in FY 1991 as the initial component of the fiber optic control system integration test. In FY 1992, preparations are underway for tests of a fiber optic position encoder and various fiber optic temperature sensors as the next step in the program. This flight experiment is expected to be completed in early FY 1993.

The materials and structures research and technology program is developing advanced materials, analysis methods, test methods and structural concepts to enable the design of safe, lightweight airframes and lightweight, durable, fuel-efficient engines. Analytical research is focused on advanced computational methods from the micromechanics level through global response of full-scale aircraft, aeroelastic response and control, and multidisciplinary design and optimization. Airframe materials and structures research is focused on understanding material fundamental behavior and fabrication technology for light metals and composites. A program was initiated to predict the oxidative degradation due to aerothermal loads of PMR-15, a high-temperature polymer being used in engine inlet rings and exhaust structures which is being considered for use in high-temperature primary aircraft structures. Computational structures technology (CST) continues to show promise in airframe and engine applications. An innovative design for a cooled turbine blade was developed for engine applications using CST methods, and local/global structural analysis demonstrated simplified modeling of a complex structure without loss of accuracy for airframe structure applications. An initial set of optimized helicopter rotor blades was fabricated to validate the integrated design research program. Experiments have been defined for a long-term aircraft structures durability test program and the first test articles have been fabricated. Successful completion of the advanced flexible wing program resulted in demonstration of significant load reduction during rolling maneuvers. In a validation experiment of "smart structures" technology, piezoelectric actuators applied to a fuselage skin reduced aircraft interior noise by an order of magnitude.

The controls, guidance and human factors research and technology program provides a technology base supporting future aircraft designs for safer and more efficient operations and greatly expanded flight envelopes. A number of technology products reached the state of maturity in which they were validated in flight and in operational field tests in FY 1992. Operational tests of air traffic controller automation aids leading to increased system capacity were initiated in cooperation with the Federal Aviation Administration (FAA). Automated nap-of-the-Earth rotorcraft guidance concepts began flight evaluation in a cooperative effort with the Army. Research in flight crucial systems focused on fly-by-light/power-by-wire applications, focusing on analytical and experimental methods for assessing electromagnetic effects on candidate system designs. The airborne windshear sensor program conducted flight evaluations of lidar (laser radar), infrared and Doppler microwave radar sensors to characterize performance in the presence of ground clutter and rain backscatter effects. Human factors research continued to focus on flight management, human engineering methods and cockpit automation aids. Flight evaluation of automated diagnostic aids, data link information transfer, and in-flight planning/replanning aids was conducted using the transportation systems research vehicle.

Flight systems research and technology addresses a broad range of needs supporting aviation safety, flight test methodologies and air vehicle advanced technology demonstration/validation. A three-year effort was initiated in FY 1991 in the icing program to assemble and assess an overall airplane computational code to predict the effects of ice on the performance and stability of swept-wing and commuter aircraft. A joint Air Force/NASA test of advanced, low-power deicer systems on the B1-B engine inlet components is also being conducted. This follows the test program on several advanced, low-power deicer systems conducted during FY 1991 to determine the more effective candidate deicer systems. The short takeoff and vertical landing (STOVL) technology program has been substantially curtailed because of budget reductions and the lack of defined service support, resulting in the termination of STOVL configuration-peculiar technology development. The STOVL program is now aimed at flight and propulsion integration, and guidance and control investigation, both of which have broad and general application to future STOVL and conventional designs. The high angle-of-attack research program continues to explore maneuverability and agility technology. Wind-tunnel and flight-data-validated prediction methods are enabling aircraft designers to develop highly maneuverable advanced concepts and to design modifications for existing aircraft to enhance performance. Advanced computational fluid dynamics methods have been used to calculate the flowfield around the full F-18 configuration and within the inlet duct with excellent correlation to data obtained from the F-18 high angle-of-attack research vehicle (HARV) flight research. The multi-axis thrust vectoring control system (TVCS) installed on the HARV is allowing unprecedented aerodynamics, controls and operations research at extreme angles of attack. The final design for the HARV mechanical forebody vortex control device has been completed. Envelope expansion into the high angle-of-attack regime is being performed on the X-31 enhanced fighter maneuverability (EFM) aircraft in support of the Department of Defense. This vehicle will explore post-stall maneuverability in the combat environment. Initial SR-71B flight tests will be completed in FY 1992, providing an evaluation of its utility and associated operational costs in a flight research environment. This evaluation and an assessment of national requirements will determine whether the SR-71 will continue to serve as a flight research testbed.

The aeronautics systems analysis element conducts long-term technology assessments, identifies technology applications, and performs sensitivity analyses and tradeoff studies from which effective research and technology programs can be developed to meet future civil and military aeronautics requirements. Studies conducted under the systems analysis element focus on defining high-leverage, long-range research and technology needs for specific vehicle classes. Current efforts include conceptual design studies and economic benefit analyses for advanced rotorcraft and subsonic transports. Other studies are investigating technology tradeoffs for hypersonic vehicles, supersonic transport, and high-performance aircraft to enable the most effective use of resources. In addition, the studies serve to develop advanced analytical techniques and design and integration capabilities.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Reductions to the aeronautics research and technology base totaling $14.9 million include $14.5 million of the $17.0 million Congressional reduction and a reallocation of $0.4 million from hypersonic research efforts to transatmospheric research and technology. These reductions will be made to research in all speed regimes; including subsonic, high-speed, high-performance, and hypersonic and will be accommodated by deferring and replanning FY 1992 activities. Within the research and technology base, $6.5 million has been reallocated to provide funding for the first year of a three-year effort to acquire a modern transport aircraft cockpit simulator (total cost $19.7 million) to support ongoing and planned research in human factors, cockpit management and safety.

The changes by the discipline programs are as follows:

The aerodynamics research and technology program has been reduced by $2.2 million which consists of a **$2.7** million reduction resulting from Congressional action and reallocation of $0.1 million to transatmospheric research and technology, offset by a realignment of $0.6 million from flight systems research and technology for severe weather research. The reductions will result in deferral and replanning of FY 1992 activities in the subsonic, high-performance and hypersonic speed regimes.

Propulsion and power research and technology was reduced by *$4.1* million. This reflects the net effect of a Congressional reduction of $4.9 million, which reduced high-speed related research, delaying the high-Mach turbomachinery program and eliminating the inlet/nozzle and controls/dynamics research associated with supersonic throughflow fans, and reallocation of $0.1 million to support transatmospheric research and technology, and a general reduction of $0.6 million which has been offset by an increase of $1.5 million to support hypersonic research facilities.

The current estimate for **materials and structures research and technology** reflects a *$4.4* million reduction. This consists of a reallocation of $0.1 million to transatmospheric research and technology and a reduction of $0.8 million resulting from Congressional action. In addition, *$3.5* million has been reallocated within the research and technology base to support other high priority requirements. These reductions will result in deferral, delay and/or replanning of some activities in the subsonic, hypersonic and high-performance speed regimes.

Controls, guidance and human factors research and technology reflects a net reduction of *$4.3* million. This includes reallocation of $0.1 million to transatmospheric research and technology, a $1.9 million reduction resulting from Congressional action, a $2.0 million general reduction, and a *$0.3* million realignment to flight systems. Within this program, *$6.5* million has been redirected to support the acquisition of a modern transport aircraft simulator cockpit to support ongoing and planned research efforts. These actions will affect all elements within the program, including panel and helmet-mounted display research, automated flight control and guidance research, and software engineering research activities.

Flight systems research and technology reflects a $1.0 million increase. This is the net effect of a number of actions including *$3.3* million reduction resulting from Congressional action and a transfer of $0.6 million for severe weather research to aerodynamics, offset by an increase of $4.6 million for flight research and facility activities at the Dryden Flight Research Facility, and a *$0.3* million realignment from controls, guidance and human factors to support optical air data system research.

Systems analysis reflects a $0.9 million reduction resulting from Congressional action, which will delay initiation of planned study activities.

BASIS OF FY 1993 ESTIMATE

Aerodynamics research and technology will continue to investigate the challenging problems which arise in a wide range of fluid flows and relate these findings to the development of advanced design techniques. Computational simulation and mathematical modeling activities will be pursued to provide an improved understanding of viscous flow physics and will result in new flow control technologies for improving aerodynamic performance of vehicles across all speed ranges. In FY 1993, emphasis will be placed on deriving fast, accurate grid generation methods and on developing three-dimensional algorithms and efficient display of computational data. Experimental activities will provide new insights into the physics of boundary layer transition and turbulence, and data for the generation and validation of advanced Reynolds stress models. Nonintrusive instrumentation research will focus on the development of advanced laser techniques which measure high-speed fluid flow velocity and temperature simultaneously. Generic hypersonics research in FY 1993 will utilize experiments on board the Pegasus launch vehicle to provide data for code validation and development of sophisticated compressible turbulence models. Research in subsonic aircraft aerodynamics will focus on advanced high-lift flap systems for improving airport capacity and noise reduction, and laminar flow techniques for reduced drag. The B-737 high-lift flight tests will be augmented in FY 1993 with companion ground-based testing in the 14x22-foot wind tunnel and a semi-span B-737 model test in the national transonic facility. A T-39 aircraft will also be used as a model for simulating a generic subsonic transport in the 40x80x120-foot national full-scale aerodynamics complex. Research efforts will also provide enabling technology for high-performance fighter/attack aircraft to acquire enhanced maneuverability, efficient store handling, and improved subsonic efficiency. Rotorcraft research will focus on the completion of flight airloads testing for maneuverability and fuselage interference experimentation. In FY 1993, supersonic cruise research will emphasize the development of airframe/propulsion integration methodologies for alternative high-speed research vehicles.

Propulsion and power research and technology will continue to emphasize improved understanding of the governing physical phenomena at the disciplinary, component and subsystem level leading to future high-payoff improvements in capability and efficiency. Discipline research will continue on development of advanced computational analysis codes that are three-dimensional and include viscous, reacting flow and heat transfer capability. Experimental and analytical evaluations will be used to determine the unsteady flow effects on heat transfer levels of high-temperature turbine blade surfaces. In addition, the conversion of the large low-speed centrifugal compressor to an axial configuration will be completed and a detailed flowfield data base will be developed for validation of three-dimensional viscous multistage turbomachinery analytical codes. Completion of the data base is estimated for FY 1994. Silicon-carbide-based electronic devices will be demonstrated that allow operation at 600' Celsius for use as smart sensors in high-temperature areas of propulsion systems. The first full fiber optic control system integration configuration that includes both electro-optical actuators and a range of optical sensors will be flight tested on an F-15 aircraft. Applied research will continue on high-pressure core concepts that offer a 20-percent improvement in thermal efficiency relative to current subsonic commercial engines and with emphasis on the basic understanding of axial turbomachinery flow fields to enable the increased stage loading at high efficiency in both the compressor and turbine required for high-pressure cores. In hypersonics research, the focus will be on improvement of inlet and nozzle analytical capability with advanced algorithms for decreased computer time to reach a converged solution, new turbulence models for increased accuracy, and dynamic grid generation techniques for more rapid change of configuration geometry.

Materials and structures research and technologv will continue to focus on enabling the design of safe, lightweight airframes and lightweight, durable, fuel-efficient engines. The toughness of LARC-RP46, a hybrid polymer matrix developed by Langley Research Center for use on high-temperature primary structures, will be improved while maintaining processibility and high mechanical properties. Advances will continue in the development of Euler and Navier-Stokes aeroelastic codes and their applications to wing flutter and separated flow analyses. A rotorcraft test article will be built to validate the integrated aerodynamic, dynamics and structures optimization approaches developed to date. A new polymeric adhesive for high-speed applications capable of withstanding 700" Fahrenheit environment will be synthesized. Work will continue in the development of residual strength and life prediction methodologies for laminated composites with efforts in **FY 1993** focusing on the mechanics of the fiber/matrix interface. The use of massively parallel computers in computational structures technology will be demonstrated. A three-dimensional aeroelastic analysis to predict flutter of the supersonic throughflow fan system will be validated by an engine wind tunnel experiment. A standardized test method for measuring crack growth and fracture resistance of brittle materials, such as glasses, ceramics and intermetallics, will be developed.

The controls. guidance and human factors research and technoloev program supports applied research in the areas of flight crucial systems, airborne windshear detection, controls for highly agile aircraft, advanced cockpit and air traffic control integration, and automated guidance and control for nap-of-the-Earth rotorcraft flight. In the area of flight crucial systems, emphasis will continue to be placed on the development and validation of design and assessment tools which support cost-effective certification of highly reliable electro-optical flight systems and on methods for automated development of reliable software. Increased emphasis will be placed on the development of analytical and experimental tools for assessing electromagnetic effects on electro-optical flight systems. Evaluations of the performance of individual airborne windshear sensors will be completed in FY 1993, and tests of an advanced airborne windshear detection and avoidance system, consisting of integrated airborne sensors and the pilot/vehicle interface, will begin. Evaluations of automated aids for air traffic controllers are underway in cooperation with the **FAA** in the Denver terminal area. In **FY 1993**, the field evaluations will be extended to include the Dallas-Fort Worth terminal area. Simulation and flight evaluation of cockpit automation aids will be conducted and increased emphasis will be placed on investigating the integration of aircraft equipped with advanced technologies, such as synthetic vision, data link and global positioning system (GPS), into the National Airspace System. Control laws designed to exploit enhanced agility capabilities of advanced high-performance aircraft will be evaluated in flight on the F-18 High Angle-of-Attack Research Vehicle (HARV). Flight evaluation of vision-based passive ranging algorithms, required for rotorcraft nap-of-the-Earth flight guidance, will be initiated. Installation of a precision GPS-based navigation system, helmet-mounted display system, and a guidance computer in the UH-60 RASCAL flight research helicopter will begin in FY 1993, with completion of the testbed estimated for FY 1996. Basic computer science research will be directed toward improving the software tools and computational techniques required to support a broad class of aeronautical applications, including multidisciplinary design and high-fidelity simulation. Fundamental research in human factors will continue to focus on developing an improved understanding of human performance and providing measures to reduce operational human errors and improve aviation safety.

In flight systems research and technology, the assessment of advanced, low-power deicing technology and an advanced ice detector for rotors will be completed, and a three-dimensional finite wing aero-performance code will be published. The high angle-of-attack research program will begin to focus on technology validation experiments. These experiments are focused on flight validation of the most promising new technologies, including advanced controls for thrust vectoring, mechanical forebody vortex controls and wide-angle helmet-mounted displays. Advanced thrust vectoring control laws designed for agility will predominate the flight research during FY 1993. Manufacture of the mechanical forebody vortex controls will occur and check-out will begin. Envelope expansion of the X-31 will be completed. The Short Takeoff and Vertical Landing (STOVL) program, utilizing both flight-test- and flight-simulation-generated data, will continue the synthesis process for the optimized integration of flight and propulsion, guidance and control systems for the STOVL terminal area operation. The flight results that will become available in FY 1993 will be a significant help in establishing the credibility of the simulation results garnered over the past several years, on guidance and control concepts utilizing integrated flight and propulsion controls. All efforts supporting specific advanced STOVL configurations have been terminated because of the uncertainty of future applications. Continued support for the design, fabrication, installation, definition and conduct of experiments benefiting the National Aero-Space Plane (NASP) and the high-speed civil transport (HSCT) provide the major focus for the SR-71 flight research testbed for FY 1993.

In FY 1993, the aeronautics systems analysis element will continue development of analytical and multidisciplinary design methods. A conceptual design process for performing engine/airframe integration analysis, including an initial engine/airframe data base, expert systems and data base management system, will be completed. Supersonic cruise studies will continue investigations of propulsion/airframe integration methods and initiate a preliminary design, including airframe integration, of a novel engine concept. Rotorcraft studies will complete development of structural design/analysis methods for tiltrotor wings, including dynamic responses, in order to provide improved weight calculations. The technology cost/benefit analysis for commercial tiltrotor will be completed. High-performance aircraft studies will initiate applications of agility metrics into aircraft design methods in order to assess technology payoffs. Studies for subsonic aircraft will complete a preliminary design of a very long-range transport to assess technology and economic tradeoffs. Hypersonic studies are investigating technology tradeoff of single- and two-stage-to-orbit vehicle concepts.

BASIS OF FY 1993 FUNDING REQUIREMENT

SYSTEMS TECHNOLOGY PROGRAMS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
	(Thousands of Dollars)				
High-performance computing and communications	17,000	17,000	17,000	35,000	RD 12-13
Materials and structures systems technology	39,900	40,100	34,100	35,500	RD 12-16
Rotorcraft systems technology	5,100	5,200	5,200	5,400	RD 12-18
High-performance aircraft systems technology	10,500	11,100	11,100	11,900	RD 12-19
Advanced propulsion systems technology	15,000	15,400	14,400	16,000	RD 12-20
Numerical aerodynamic simulation	44,100	45,400	45,400	47,000	RD 12-22
High-speed research	44,000	76,400	71,600	89,900	RD 12-23
Advanced subsonic technology	--	5.000	5.000	12,300	RD 12-27
Total	175,600	215.600	203.800	253.000	

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
High-performance computing and communications.......	17,000	17,000	17,000	35,000

OBJECTIVES AND STATUS

The High Performance Computing and Communications (HPCC) program is a multi-agency endeavor which involves NASA, the Department of Energy, the National Science Foundation, the Defense Advanced Research Projects Agency, the Department of Commerce, the National Institutes of Health, the Environmental Protection Agency, and the Department of Education. The program is an integral part of the Administration's strategy for national leadership, as expressed in "Grand Challenges: High Performance Computing and Communications,'' a supplement to the President's Fiscal Year 1992 and 1993 Budget. NASA's role in the national program includes acquiring experimental hardware for testbeds and developing software and algorithms in computational aerosciences and Earth and space sciences, and supporting the development of the National Research and Education Network. The goal of NASA's portion of HPCC is to accelerate the development and application of high-performance computing technologies to meet NASA's science and engineering requirements. This program will enable teraflops (10^{12} floating point operations per second) computer capabilities essential for computational design of aerospace vehicle systems and for predicting long-term global climate change.

NASA has been a leader in advanced computational sciences and is in a position to exploit high-performance computing to more efficiently achieve NASA goals. The NASA HPCC program is focused to enable broad advances in aerospace vehicle design and Earth and space systems science programs. During FY 1992, NASA has made significant progress, including release of a NASA Research Announcement (NRA) and award of grants to multidisciplinary research teams to support the Earth and space sciences project, and being a key contributor to, and member of, the Concurrent Supercomputing Consortium for the acquisition and use of Intel Corporation's massively parallel Delta Touchstone supercomputer installed at the California Institute of Technology. NASA has established supercomputer testbeds at its Ames, Langley, and Lewis Research Centers and the Jet Propulsion Laboratory using Intel iPSC-based systems, and at Goddard Space Flight Center with a MasPar MP-1. In addition, NASA sponsored a three-day series of meetings between the top fourteen companies involved with supercomputers in the U.S. and representatives from the major federal agencies.

In advanced software technologies and algorithms, NASA began initial implementation of a National High Performance Computing Software Exchange experiment which will provide a mechanism for computational researchers in federal agencies, industry and academia to share and coordinate algorithms and applications software. NASA, along with other federal agencies, sponsored and participated in a major systems software workshop during FY 1992 which assessed the current state-of-the-art and future requirements in systems software and tools. In FY 1992, a variety of algorithms and applications codes will be ported to massively parallel machines. These included a high-speed civil transport aerodynamic code and a Navier-Stokes solver on the Ames Research Center testbed. An improved unstructured grid methodology was developed. In addition, the suitability of various parallel architectures for a representative set of algorithms and code kernels was evaluated. A high level language preprocessor for parallel architectures was delivered. The evaluation of multiple instruction, multiple data (MIMD) systems software support tools was initiated.

NASA also completed 45 megabits per second interconnects between the major NASA testbeds and the National Research and Education Network. These interconnects are essential to provide industrial and university researchers access to NASA testbeds. In addition, during FY 1992, NASA began the installation of network services to provide 45 megabits per second interconnect capability among five NASA centers.

Basic research and human resource development for high-performance computing and communications has been augmented in FY 1992. These efforts include in-house activities to develop advanced algorithms for multidisciplinary applications on parallel computing testbeds, as well as university efforts through the Institute for Computer Applications in Science and Engineering (ICASE), the Research Institute for Advanced Computer Science (RIACS), the Institute for Computational Mechanics in Propulsion (ICOMP), and the Center of Excellence for Space Data and Information Sciences (CESDIS).

BASIS OF FY 1993 ESTIMATE

In FY 1993, the HPCC program is focused on two areas of application: (1) integrated, multidisciplinary computational aerospace vehicle design; and (2) multidisciplinary modeling and analysis of Earth and space science physical phenomena.

Grand Challenge software applications research will proceed in two distinct projects: computational aerosciences (CAS) and Earth and space sciences (ESS). The CAS project will direct its efforts towards continuing the development of multidisciplinary algorithms and advanced software technology in four areas: high-speed civil transport (HSCT); powered lift; National Aero-Space Plane-derived vehicles; and aerobraking. The ESS project will select and support four to six multidisciplinary teams. The research teams will be selected from problem areas, such as Earth systems science, biogeochemical life-cycles, planetary evolutionary processes, space and solar-terrestrial physics, and astrophysics and astronomy.

Testbeds are a crucial part of this program because they provide a key tool for interdisciplinary research teams to develop and evaluate applications and systems software and to evaluate scalable hardware architectures and peripherals. NASA has considerable expertise with experimental parallel computer testbeds. A key to successful exploitation of massively parallel computing power will be the blending of application-driven and architecture-driven computer systems and software to most effectively meet NASA's needs. Two prototype testbeds of 3 to 10 gigaflops will become operational in FY 1993, and two testbeds of 50 to 100 gigaflops will become operational in FY 1995. The testbeds will not be replacements for the numerical aerodynamic simulation (NAS) system or any of NASA's other computational facilities, but rather will serve as proof of concept of systems which, when scaled up and properly supported for operational use, could be used by those computing facilities.

Systems software to be developed under this program includes operating systems, compilers, programming environments and visualization software. Some important operating system developments include dynamic load balancing of the processors in parallel and distributed systems, and operating systems which permit heterogeneous computing. Of additional importance will be the programming languages, compilers and programming environments because they are the algorithm developers' interface to the high-performance computing system.

Debugging programs on massively parallel and/or distributed systems is significantly more difficult than on more traditional systems. This area of research requires the development of new techniques and their incorporation into systems to aid user productivity. Interim system software will be completed in FY 1994 and the final systems software suite will be completed in FY 1997.

The testbed systems must be on a research network to allow access by others working in support of the federal HPCC program. Only through such networking will applications developers have access to a broad range of architectures. Through cooperation with other federal agencies, NASA is networked into the National Research and Education Network. Systems software designers, systems architects and applications developers are working together on these testbeds to attack NASA's grand challenges. Interconnects at 45 megabits/second among five NASA centers will become operational for research purposes in FY 1993. Also, NASA interconnects to the National Research and Education Network, at 45 megabits/second, will become operational in FY 1993.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Materials and structures systems technology	**39,900**	**40,100**	**34,100**	**35,500**

OBJECTIVES AND STATUS

The objective of the materials and structures systems technology program is to develop advanced materials and structural concepts for future advanced aircraft propulsion systems and primary structures. The program is conducted in two tasks, one focused on advanced high-temperature engine materials technology and the other focused on advanced composite technology for airframe structures.

The advanced high-temperature engine materials technology program is a focused laboratory-scale materials and structures research program with application to the complete range of aircraft propulsion systems, including rotorcraft, subsonic and supersonic transports. Major consideration is being given to propulsion systems that will be friendly to the environment in terms of minimizing pollution and noise, and that will be economical via reducing fuel consumption and direct operating costs while extending life and improving reliability. These goals require very high thrust-to-weight (20 to 1) gas turbine engines with durable, long-life, high-temperature components. Key to these applications are ceramic matrix composites (CMC's), metal matrix composites (MMC's), intermetallic matrix composites (IMC's), and polymer matrix composites (PMC's) which can endure sustained operation without cooling air. Advanced analysis, design and life prediction methods are being developed for these materials to provide an understanding of composite architecture, processing, fiber/matrix interaction, and failure mechanisms at temperatures up to 3000° Fahrenheit. Supporting technologies are also being developed in the areas of high-temperature instrumentation, nondestructive evaluation, and aerodynamic/thermodynamic loads definition. Efforts in FY 1992 focused on evaluation of advanced high-temperature PMC materials, validation of high-temperature composite mechanics codes for IMC's, and identification of the environmental and microstructural factors limiting use temperature and life of CMC's, and laboratory demonstration of new PMC, IMC and CMC materials for propulsion system applications.

The objective of the advanced composite materials systems technology program is to develop innovative cost-effective structural concepts and fabrication processes to more fully exploit the advantages of composite materials in primary structures of future aircraft. While the current demonstrated level of composites technology can promise improved aircraft performance through reduced structural weight, it does so at an inhibiting increased cost. Further development of the technology is pursued through material formulation and processing refinements, innovative fabrication concepts with their resulting unique structural configurations, and analytical developments for improved structural behavior prediction. The improved technology levels will be demonstrated and validated by fabrication and testing at the subcomponent and subscale component levels. The program goals are to develop technology that will reduce airframe structure acquisition costs by 25 percent and structural weight by 30 to 50 percent relative to current airframe design and fabrication techniques. In order to achieve these program benefits, a new approach to composite design must be developed and integration of design concepts and advanced fabrication techniques using new material forms must be established. Understanding of failure mechanisms and behavior under complex loadings is critical to establishing the data base for innovative design with composites. This program is focused on new structural concepts such as stitching, multidirectional weaving, pultrusion, resin transfer molding, and advanced fiber placement. Improved resin formulations for optimized processing in resin transfer molding and fiber placement have been developed. Equipment for economical stitching of fabric preforms has been designed and produced. Composite panels representative of fuselage crown sections and integrally reinforced wing skins have been fabricated by fiber placement and resin transfer molding. Significant progress has been made toward mechanical and physical properties characterization of the materials and structural concepts. A composite parts cost data base has been initiated. Two technical conferences have been held to disseminate results to airframe manufacturers and materials suppliers.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The materials and structures systems technology program reflects a $6.0 million reduction. One element consists of a $2.5 million reduction to advanced composite materials technology resulting from Congressional action. This reduction will reduce planned activities in defining the performance and durability of high-temperature composites applicable to supersonic cruise aircraft. An additional $3.5 million was reallocated to Transatmospheric research and technology from advanced composite materials systems technology resulting in a deferral in the fabrication of medium-scale component benchmark test articles for validation of cost projections and structural performance predictions.

BASIS OF FY 1993 ESTIMATE

For FY 1993, the advanced high-temperature engine materials element will continue the development and characterization of high-temperature PMCs, IMCs and CMCs. High molecular weight polymers will continue to be evaluated for high-temperature PMC's. IMC efforts will focus on continued development and demonstration of fibers and fiber coatings, optimization and demonstration of composite fabrication processes, and development and verification of analytical and nondestructive evaluation methods. CMC efforts will concentrate on: (1) development of small-diameter ceramic fibers/coatings that are stronger and more creep resistant than current fibers, (2) continued investigations into the environmental and microstructural factors limiting CMC use temperature and life, (3) development and verification of analytical methods for predicting the reliability of CMC structures, and (4) the development and demonstration of high-temperature test methods and nondestructive evaluation methods. A verified data base at high-temperature materials for component development will be available by FY 1996.

During FY 1993, the major emphasis in advanced composite design and fabrication will continue to be on three techniques to reduce acquisition costs, namely advanced fiber tow placement, resin transfer molding, and woven textile preforms. Research will be directed toward exploiting and verifying these new composite fabrication and design concepts. In FY 1993, a new powder coating process for fibers will be used, with both thermoplastic and thermoset resins, to economically produce composites of three-dimensional woven fabric. A design data base and set of guidelines will be initiated for textile material forms that can achieve improved damage tolerance and increased post-buckling strength. FY 1993 will also see the first combined shear and biaxial inplane loading tests of composite fuselage panels, as well as combined pressure and mechanical loading tests of a subscale fuselage barrel section. A twelve-foot box beam representative of an all-composite wing box will be fabricated, exploiting the techniques of stitching and resin transfer molding. Analytical methods for impact dynamics of unique advanced composite technology test components will be exercised to demonstrate the improved crashworthiness of the composite structures over baseline all-metal designs. Probabilistic structural analysis methodology will be exercised. Potential polymer-based composites for up to 400° Fahrenheit service temperature will be refined, and assessment of their structural service life capability will continue. The cost benefits of the new structural concepts will be verified by fabrication of multiple replicates and an analytical cost model will be verified. The fourth advanced composite technology technical conference will be held as a forum for the dissemination of this technology.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Rotorcraft systems technology	5,100	5,200	5,200	5,400

OBJECTIVES AND STATUS

The rotorcraft systems technology program is focused on integrating technologies for noise reduction and promising opportunities for tiltrotor aircraft.

In FY 1992, NASA identified the highest priority areas for research in tiltrotor aircraft and the associated research goals. Noise remains at the top of the list. Preparations were made for a major comprehensive noise assessment of the V-22 tiltrotor in cooperation with the U.S. Navy and the Federal Aviation Administration (FAA). Data from FY 1991 testing of the XV-15 tiltrotor with advanced technology blades was used for calibrating the NASA-developed comprehensive noise prediction code (ROTONET). Simulations of steep approaches for noise abatement were made in conjunction with the FAA. In cooperation with the U.S. Army, work was begun on the design of a tiltrotor aeroacoustic model (TRAM) for detailed airloads testing in low-noise wind tunnels.

In order to meet an 80-percent noise reduction goal, relative to currently available technology, several promising innovative concepts were tested in small scale. Each had various compromises in complexity, performance and noise reduction. Analysis will determine which concepts will be carried to full scale. Also in FY 1992, fabrication of a large rotor test apparatus will continue in cooperation with the Army for use in the 40x80-foot wind tunnel complex. Fabrication will be complete in FY 1993. It will handle larger rotors such as those used on the AH-64, UH-60 and V-22.

BASIS OF FY 1993 ESTIMATE

Comprehensive noise testing will conclude on the V-22 and the advanced bladed XV-15. The XV-15 tiltrotor, after a year of refurbishment, is also scheduled to fly certification profiles for noise abatement, examine failure modes, and handling qualities. Preparations will be underway to test several tiltrotor blades in the 80x120-foot wind tunnel for detailed noise measurement, particularly in the conversion/landing mode. The tiltrotor aeroacoustics model (TRAM) will begin fabrication. In more general noise reduction research, one systems-level concept will be selected for full-scale investigation in cooperation with industry.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
High-performance aircraft systems technology	10,500	11,100	11,100	11,900

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This program generates validated methods and design data applicable to the development of advanced high-performance aircraft applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel testing, and flight research involving tests of advanced aircraft concepts and systems.

The high angle-of-attack research program combines wind tunnel and computational results with a flight-validated data base for design of highly agile aircraft. The F-18 high angle-of-attack research vehicle (HARV), equipped with the thrust vectoring control system (TVCS), will complete envelope expansion and aggressively pursue aerodynamics, controls and operations research.

The F-15 highly integrated digital electronics control (HIDEC) aircraft continues to demonstrate the capability to actively determine and adjust critical engine operating conditions with real-time parameter identification, resulting in a very significant increase in the engine life throughout the full flight envelope or a substantial improvement to the specific fuel consumption and engine performance.

The vertical/short takeoff and landing (V/STOL) research aircraft (VSRA) YAV-8B Harrier flight research program investigates guidance/display schemes, and integrated flight and propulsion concepts for the hover and transition flight regimes. During FY 1992, the VSRA modification to the propulsion control system will be completed, providing a highly versatile, digitally implemented longitudinal and propulsion control system to properly support the continuing investigations critical to future integrated flight and propulsion envelopes.

Two F-16XL testbed aircraft are used for flight research operations in the high-speed research. The results of flights by these testbeds will also be applicable to future supersonic military aircraft.

BASIS OF FY 1993 ESTIMATE

Flight research using advanced flight control laws designed for agility will be flown on the F-18 HARV with the TVCS. The full-envelope flight evaluation on the F-15 HIDEC of the two-engine performance seeking control system will be successfully completed. Flight research operations in support of the high-speed research program will continue through FY 1993 using the F-16XL aircraft. The VSRA YAV-8B Harrier will, for the first time, be able to utilize the digitally implemented propulsion and flight control systems as part of the verification and validation of the control and guidance schemes evaluated on the vertical motion simulator over the past several years.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Advanced propulsion systems technology	*15,000*	*15,400*	*14,400*	**16,000**

OBJECTIVES AND STATUS

The objective of the advanced propulsion systems technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components.

Activities in the advanced turboprop systems program are devoted to establishing the feasibility of low-noise ultra-high bypass concepts and providing the broad research and technology analytical and experimental data base necessary for achieving maximum source noise reduction for subsonic propulsion systems. In FY 1991, an advanced ducted propulsion model was experimentally evaluated at takeoff conditions to determine the aerodynamic performance of short, thin low-drag nacelles at high angle-of-attack, reverse thrust capability of reverse pitch fans, noise levels of a ducted propeller concept, and to establish a data base for validation of an advanced three-dimensional viscous flow code under development. In FY 1992, the model will undergo experimental evaluation at cruise conditions to determine performance and noise levels. It will then be combined with an advanced wing design to determine integration characteristics at takeoff conditions as well as integration effects on noise levels. Research is being initiated in FY 1992 to demonstrate the potential of active noise control of engine source noise. An experiment to actively control plane wave noise of a small turbofan engine resulted in a seven-decibel reduction from uncontrolled levels using acoustic speakers to generate an inverse noise signature in the inlet duct.

In the general aviation/commuter engine systems technology program, the objectives are to raise the performance level of small turbine engines to approximately that of large transport turbine engines, requiring a 30 percent decrease in fuel consumption. Research continues on radial flow turbomachinery which has the potential to reduce the impact of small components on propulsion system efficiency. The work is focused on providing a detailed understanding of the design parameters that affect component performance through the development of analytical codes and the associated experimental data base for validation. In FY 1991, an uncooled version of a cooled radial turbine design was tested with excellent aerodynamic results. In FY 1992, the cooled version will be tested for heat transfer effectiveness and performance. Final preparations have also been made for an FY 1992 high-speed centrifugal compressor experiment that will use nonintrusive instrumentation to develop a detailed flow field data base with compressibility effects for validation of advanced analytical codes.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The advanced propulsion systems technology program reflects a reallocation of $1.0 million to Transatmospheric research and technology from advanced turboprop systems technology program reducing and delaying research focused on active control techniques for both cabin interior noise reduction and propulsion source noise reduction.

BASIS OF FY 1993 ESTIMATE

In FY 1993, the emphasis in advanced turboprop systems research will continue to be the understanding and control of source noise mechanisms, propulsion/airframe installation aerodynamics, and the development of improved aerodynamic, structural and acoustic analysis techniques for ultra-high bypass subsonic propulsion systems. An analytical code will be completed that predicts the source noise of a ducted propeller propulsion system using an integrated aerodynamic, structures and acoustics analysis approach. This analytical capability will be used to help design an experiment that will attempt to actively control noise at the fan source. Installation aerodynamics research will include an FY 1993 wind tunnel evaluation of the advanced ducted propeller model and wing to determine the effect of the presence of a wing on reverse thrust capability. A three-dimensional unsteady viscous flow code will be completed in FY 1993 for ducted ultra-high bypass systems that provide the aerodynamic basis for analytical evaluation of advanced low-noise concepts including the effects of the nacelle and multiple rows of turbomachinery.

The general aviation/commuter engine technology effort will continue to demonstrate component improvements through the practical application of validated analysis codes that will enable high-performance small engine systems. Recently completed high-temperature combustor ceramic liner experiments and the completion of a three-dimensional Navier-Stokes two-phase reacting flow code will provide the required design input for demonstration of an advanced combustor with a very aggressive pattern factor of 0.1 at a combustor exit temperature of 2800' Fahrenheit. Component demonstrations are estimated for completion by FY 1996. For turbomachinery, high-speed radial inflow turbine and centrifugal compressor experimental data will be used for validation of a three-dimensional viscous analytical capability that predicts aerodynamics and heat transfer in radial flow turbomachinery.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Numerical aerodynamic simulation......	*44,100*	*45,400*	*45,400*	*47,000*

OBJECTIVES AND STATUS

The numerical aerodynamic simulation (NAS) program objective is to significantly augment the nation's capabilities in computational fluid dynamics (CFD) and other areas of computational physics by developing a preeminent computational capability for the numerical simulation of aerodynamic flows. The NAS system continues its national operation, with close association with other NASA programs, the Department of Defense, other government agencies, industry and academia. Ongoing research and technology base efforts in computational aerodynamics continue to benefit significantly from the advanced computational capabilities provided by the NAS program. This program provides the computing power not available from central operational facilities required to obtain solutions to problems which may be interactable on less than state-of-the-art computer systems, including solutions to the full Navier-Stokes equations, enabling performance predictions for complex aircraft geometries. In order to ensure this degree of computational capability, the NAS program continues to implement the following efforts: (1) acquire pathfinding, state-of-the-art, high-speed processors **(HSP's)**; (2) provide a uniform, balanced, user-friendly system with equivalent capabilities for local and remote users; (3) maintain an auxiliary processing center for secure processing; *(4)* investigate and incorporate parallel architecture machines into future generations of the NAS; *(5)* develop a hardware and software environment for prototyping and testing of computers, networks, storage devices, workstations and graphic output devices; and *(6)* continue to research and enhance an increasingly sophisticated system of hardware/software tools and environments to assist the user in performing CFD tasks efficiently.

During FY 1991, the following hardware upgrades have been completed in order to provide efficient total system support for the HSP's. This process of continual subsystem upgrades is a part of the planning which provides for future HSP's as well. Mass storage capacity was increased to 4.8 terabytes, enabling quickly available data storage consistent with HSP output capability. The AERONET supplanted NASNET as the long-haul communications network replacing older, switched networking with a newer routed (more reliable and efficient) network. The next generation workstation contract has provided a mechanism for installation of efficient workstation interfaces to the HSP throughout the NAS system. To meet the challenge of providing increased operational computing capability for aerospace applications, pathfinding research continues with mapping of specific aerodynamic simulation problems onto advanced computational platforms. The two NAS parallel testbeds have been moved from the development laboratory to NAS operations for use by any NAS user. During FY 1991 and continuing into FY 1992, operating, user interface and visualization software research continues with emphasis on the incorporation of expert systems and distributed systems technology. Expanded efforts in surface modeling and grid generation are underway to provide significant reductions within five years in this most time-consuming portion of the CFD process.

BASIS OF FY 1993 ESTIMATE

The number of accounts will be maintained around its current level (between 1300 and 1400) continuing the diverse use of the system by NASA, the Department of Defense, other government agencies, industry and academia. A third high-speed processor to replace the first such machine is scheduled to be placed in operation in early FY 1993. Other hardware and software elements of the extended operational configuration will continue to be enhanced as part of the continual process for development of future versions of the NAS.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
High-speed research	44,000	76,400	71,600	89,900

OBJECTIVES AND STATUS

Studies have indicated that, with sufficient technology development, future high-speed transport aircraft could be economically competitive with long-haul subsonic aircraft. Currently, however, critical environmental concerns about atmospheric impact, airport noise and sonic boom present powerful private sector disincentives. The high-speed research program is addressing these barrier environmental issues and developing the basis for evaluating technology advances that can provide the necessary environmental compatibility.

The atmospheric effects element of the program is providing theoretical and experimental research to assess the impact of stratospheric aircraft. Primary issues being addressed include depletion of ozone, perturbations to atmospheric chemistry on a global scale, and the potential for long-term climate change. A hierarchy of theoretical models is being developed and applied with the assistance of laboratory and in-flight measurements to reduce the current uncertainties in predictions made with existing global models. In FY 1992, a comparison of the six atmospheric models used in the FY 1991 baseline assessment will be performed to identify and resolve prediction differences between the models. In addition, two major field campaigns will be conducted with research aircraft platforms and newly developed instrumentation to gather key atmospheric information for further model calibration and refinement. Propulsion and aircraft system studies are also being conducted in this element of the program to provide a framework for related technology efforts through identification of key technology needs and assessment of commercial viability of proposed solutions. During FY 1992, engine and airframe manufacturers will be narrowing the number of candidate concepts through aircraft installation and mission analysis studies that incorporate small-scale model testing results.

The emissions and source noise element of the program is providing the technology base for reduced engine emissions and exhaust noise by developing improved analytical models, performing laboratory-scale experiments, and testing engine-level components to confirm the feasibility of meeting environmental goals, such as Federal Aviation Regulation (FAR) 36, Stage 3 noise levels. During FY 1991, flame tube experiments of two low nitrogen oxide (NO_x) combustion concepts, lean premixed, prevaporized (LPP) and rich-burn, quick-quench, lean-burn (RQL), were completed and achieved measured NO_x values below the 90-percent reduction program goal. Experimental testing of advanced design low-noise nozzle concepts will be conducted in FY 1992 to determine if improving the internal mixing reduces exhaust noise, and to also obtain fundamental flowfield and noise data for use in verification of analytical aerodynamic and acoustic prediction techniques.

The objectives of the community noise and sonic boom element are to develop advanced aerodynamic and aircraft configuration technologies that are integral to lowering takeoff and landing approach noise and to achieving sonic boom signatures that may be acceptable for operation in limited overland corridors. Meeting the airport noise objective requires the development of accurate noise reduction prediction methods on a complete aircraft system level, development of efficient wing high-lift systems, evaluation of engine placement effects, and optimization of landing and takeoff procedures. In FY 1991, specific promising high-lift devices were identified through wind tunnel evaluation. In FY 1992, these high-lift systems will continue to be developed with theoretical analysis, small-scale wind tunnel investigations, and piloted simulator studies in order to evaluate their noise reduction payoffs. Sonic boom research is focusing on human acceptability criteria, as well as the development of low-boom configuration concepts and predictive methodologies. In FY 1991, wind tunnel tests of initial low-boom aircraft configurations were completed, and sonic boom simulation experiments were developed to establish an acceptability data base. In FY 1992, wind tunnel investigations of second generation low sonic boom aircraft designs, which possess minimal aerodynamic penalty while achieving the desired low-boom characteristic, will be conducted. The human response data base will also be expanded through in-home simulation surveys. Laminar flow control research for aerodynamic drag reduction is also a key part of this element due to its potential for reducing aircraft and engine size which would have a favorable impact on the aircraft's noise, sonic boom and atmospheric effects. Efforts during FY 1991 included a study of swept-wing crossflow effects in a low-disturbance wind tunnel and the development of boundary layer transition sensors for future flight experiments. In FY 1992, low-disturbance wind tunnel investigations will continue with advanced models that can provide variations in flow parameters, including suction for laminar flow control, flight research on modified leading edges for the F-16XL aircraft, and the initiation of the design of a 60-percent laminar flow wing modification for the F-16XL.

The objective of the enabling propulsion materials element, which began in FY 1992, is to develop advanced high-temperature composite material systems which will provide critical enabling capabilities to meet the requirements of low-emission, low-noise turbine engines for future high-speed civil transport aircraft. Key to the success of this program is the development of strong, stiff, lightweight, oxidation-resistant reinforcing fibers and matrix materials which are capable of maintaining chemical stability and mechanical properties at temperatures up to 3000° Fahrenheit. The research is focused on developing advanced ceramic matrix composites (CMC's) for the combustor liner and intermetallic matrix composites (IMC's) for the exhaust nozzle, and emphasizes fiber and fiber coatings development, cost-effective fabrication and joining technology, and life prediction and failure analysis methods.

In FY 1992, combustor and nozzle preliminary design studies will be conducted and initial primary and alternate materials will be identified. Fiber property goals will be set for both the combustor liner and exhaust nozzle materials (CMC's and IMC's), and preliminary material systems test plans and nondestructive evaluation plans will be prepared.

CHANGES FROM FY 1992 BUDGET ESTIMATE

A total of $4.8 million was reallocated from the high-speed research program to Transatmospheric research and technology. This will reduce some research activities in emissions and noise reduction, aerodynamics, and enabling propulsion materials.

BASIS OF FY 1993 ESTIMATE

In FY 1993, the high-speed research program will submit an interim assessment of the atmospheric effects of stratospheric aircraft to the National Academy of Sciences for a critical review. The assessment will be based on improvements of chemistry and dynamics simulations to be incorporated in the related atmospheric models, and will include testing of the models against standard data sets and newly analyzed satellite data. Additional aircraft-based measurements to further validate the models will be obtained in conjunction with the upper atmosphere research program's antarctic polar ozone campaign, and development of the Perseus semi-autonomous aircraft will be completed to assist later field experiments. Industry and government system studies will continue in support of the atmospheric assessment, as well as the specific propulsion and airframe technology developments to assess overall program progress and to guide future research directions and priorities.

Sector rig tests of lean premixed, prevaporized (LPP) and rich-burn, quick-quench, lean-burn (RQL) combustor concepts will be completed during FY **1993.** Based on both the sector rig test results and previously completed flametube experiments, a combustor concept will be selected to proceed with the verification of NOx reduction goals in a full annular rig which combines all of the subcomponents and components of an actual engine combustor. Results of the scale-model noise suppressor and high-lift experiments will be assessed to determine the potential to achieve the FAR 36, Stage 3 community noise goal in a full-scale aircraft system. ***An*** initial evaluation of broadband noise reduction liner configurations will be completed to determine if acoustic liners will augment the noise reduction capability of mixer-ejector nozzle concepts.

Research will continue to develop and refine the most promising high-lift system concepts and low sonic boom configurations. Development and evaluation of supersonic laminar flow control to reduce aircraft drag and weight will continue with wind tunnel tests and an F-16XL aircraft flight investigation of boundary layer transition characteristics for the highly swept wings of a high-speed civil transport. The development of a wing glove designed to achieve 60-percent laminar flow on the **F-16XL#2** aircraft will be finalized in preparation for flight research.

For the enabling propulsion materials program in FY **1993**, alternate materials, fabrication processes and design concepts will be identified for both the combustor liner and the exhaust nozzle. The CMC material selection will be made based on a critical technical assessment of candidate materials and fabrication processes. The CMC fiber and fiber coating development and characterization plans will be prepared. Material coating requirements will be identified and CMC fabrication scale-up and joining technology development plans will be prepared. Preliminary screening tests of candidate IMC's will also be conducted, and IMC fabrication scale-up and joining technology development plans will be prepared. Available analytical methods and computer codes for prediction of failure modes and damage initiation/accumulation/growth will be assessed, and benchmark test plans for analytical methods verification will be prepared.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Advanced subsonic technology	--	5,000	5,000	12,300

OBJECTIVES AND STATUS

The objective of the advanced subsonic technology program is to accelerate the development of key high-payoff technologies to maintain the performance/cost advantage of U.S. subsonic transport aircraft in the world market, and to ensure their efficient and safe operation in the National Airspace System. Substantial growth is projected in the number of subsonic transport aircraft required to meet future transportation demands.

Air traffic worldwide is projected to double between 1988 and the turn of the century. This high demand will result in both a large new aircraft market opportunity for U.S. industry and delayed retirement of older aircraft, doubling the number of in-service aircraft over twenty years old by the end of this decade. The objective of the aging aircraft program is to develop technology required to ensure the long-term structural integrity of aging civil transport aircraft. Current technology for quantitative nondestructive evaluation of airframe structures for disbonds, fatigue cracks and corrosion is inadequate. During 1992, cost-effective, large-area nondestructive evaluation technology with advanced sensor and signal processing concepts is being initiated. Specific high-priority technology will focus on the development of cost-effective nondestructive evaluation technology for rapid automated wide-area inspection of disbonds, fatigue cracking and corrosion damage in older transport aircraft. Fatigue and fracture analysis methodology for aircraft structures examining fatigue crack growth for riveted joints with multisite fatigue damage is being developed. Global/local analysis procedures for relating localized failure mechanisms to overall structural integrity continues to be developed and verification of the structural fatigue analyses has begun.

Fly-by-light/power-by-wire (FBL/PBW) technology has the potential to provide lightweight, highly reliable, electromagnetically immune control and power management systems for new transport aircraft. Technology will be developed for confident application and certification of integrated FBL/PBW. Efforts will be focused on optical components and subsystems, an advanced electrical power management and distribution system, development of analytical and experimental methodologies for assessing electromagnetic environment effects, and development of system architecture designs and validation methods appropriate for certification. Optical sensor technology under development for the fiber optic control system integration program was accelerated and broadened to include full system architecture design issues and transport aircraft application. The FY 1992 focus is on development and test of optical components and assessment of electromagnetic effects (EME).

BASIS OF FY 1993 ESTIMATE

The aging aircraft program builds on NASA's extensive expertise in acoustic, ultrasonic and thermal nondestructive evaluation methods, fatigue of metallic materials, and stochastic modeling for structural life prediction. Focused development of these technologies provides advances in rapid, cost-effective inspection and analysis procedures for improved safety of current and future airframe structures. Specific milestones for the FY 1993 aging aircraft program include verification of fatigue crack growth predictions for multisite damage in flat plates, extension of the fatigue crack growth analysis methods to stiffened shells, and demonstration of several nondestructive inspection techniques, including ultrasonic, optical, magnetic, thermal and radiographic, for rapid evaluation of large areas. These NASA activities are being carried out on a cooperative basis with the Federal Aviation Administration (FAA) and the air transport industry to form a coordinated national effort in aging aircraft research and development.

In the FY 1993, the fly-by-light(FBL)/power-by-wire (PBW) program, optical component development and electromagnetic effects **(EME)** assessments will be conducted with emphasis on the analytical and experimental assessment methods. These methods will be integrated as part of the requirements analysis. Development of power components will be initiated. The system requirements preliminary design will be defined and transferred to the research teams within the program. The fault-tolerant architecture will be specified. The power management and distribution for the PBW system will be defined. The FBL sensors will be selected based on needs identified through the architectural design.

BASIS OF FY 1993 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Research operations support	(235,310)	(281,812)	210,100	243,200

OBJECTIVES AND STATUS

Research and operations support funding provides vital support to the civil service workforce and to the physical plant at the centers and at NASA Headquarters. Support to the civil service workforce includes provision of the basic tools to work productively such as telephone and mail service, office supplies, equipment and furniture, and the basic photo, printing and graphics shops. Support to the workforce also includes funding the support contractors, supplies and equipment necessary to provide personnel, payroll, medical and other administrative services. Support to the physical plant includes payment for center utilities, rental of buildings and space, and necessary fire protection, janitorial, and security services. Support to the physical plant also includes maintenance of roads and grounds and the maintenance of general purpose facilities such as administrative buildings and the extensive utilities systems.

CHANGES FROM FY 1992 BUDGET ESTIMATE

These activities were previously funded in the Research and Program Management/Operation of Installation appropriation. FY 1992 Congressional action both sharply reduced the requested funding for these activities, shown in parentheses, and authorized their transfer into the Research and Development and Space Flight, Control and Data Communications appropriations. This transfer has allowed the reduction to be accommodated with minimum impact by allowing the programs to fund some of the activities that had previously been covered by these funds.

BASIS OF FY 1993 ESTIMATE

NASA is in the process of deciding exactly how the activities previously budgeted in the Operation of Installation account will be budgeted in future years. The FY 1993 estimate represents the amount required to provide the basic minimum institutional support, and it will be necessary to develop mechanisms that either allow this estimate to be supplemented by program funds or that incorporates some of the funding for these activities in the program budgets.

TRANSATMOPHERIC
RESEARCHTECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Transatmospheric research and technology	95.000	32.000	20.000	80.000	RD 13-2

Distribution of Program Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Stennis Space Center	190	--	--	--
Marshall Space Flight Center	122	--	100	100
Ames Research Center	2,726	4,400	3,200	2,400
Langley Research Center	8,824	7,500	7,900	4,800
Lewis Research Center	3,737	5,300	3,100	3,200
Headquarters	79.401	54.800	5.700	69.500
Total	95.000	72.000	20.000	80.000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY CHNOLOGY

OBJECTIVES AND JUSTIFICATION

The Transatmospheric Research and Technology program is NASA's portion of the joint NASA/Department of Defense (DOD) National Aero-Space Plane (NASP) program. The program objective is to develop and then demonstrate, in an experimental flight vehicle, the technology required to permit the nation to develop reusable, single-stage-to-orbit (SSTO) vehicles with airbreathing primary propulsion as well as horizontal takeoff and landing capability.

The NASP program has progressed well into Phase 2, the period for developing the technology base and an initial definition of the X-30, the NASP experimental vehicle. Important work remains in propulsion, materials and structures, controls, aerodynamics and applications of computational fluid dynamics. Phase 3 will consist of the detailed design, construction, and flight test of the X-30. The decision on whether to move into Phase 3 in FY 1994 will be based on a comparison of technology readiness with specific criteria in FY 1993.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The Transatmospheric Research and Technology program has been reduced by $52 million. This net decrease is the result of a reduction of $67.0 million consistent with Congressional direction, current planning is to reallocate $15.0 million from Aeronautics Research and Technology ($9.7 million) and Space Research and Technology ($5.3 million). The reallocated funds will primarily support technology component testing and reinstate technology work packages which would otherwise be eliminated or postponed. Overall the schedule is expected to be delayed by approximately six months. The decision on Phase 3 and whether to build the X-30 flight research vehicle has been deferred until the last quarter of FY 1993.

BASIS OF FY 1993 ESTIMATE

NASA, other Government agencies and the team of NASP prime contractors will continue the full spectrum of technology development as well as initial definition of the vehicle concept in FY 1993. The contractor team consists of three airframe companies (General Dynamics, McDonnell-Douglas, and Rockwell International) and two engine companies (Pratt & Whitney and Rocketdyne). The integration of the contractor efforts into a limited joint-venture partnership has brought with it the benefits of technological sharing and of focusing on a single, new vehicle concept.

Activities in **FY 1993** will be directed toward enabling a decision to proceed into Phase **3** as well as ensuring a smooth transition from Phase **2**. A series of specific technology-development tasks assigned to NASA research centers will utilize the unique expertise of the NASA personnel. In other areas, NASA will support tests by contractors in NASA facilities to build the essential data bases in new technology areas. Airframe work will focus on total design integration, advanced materials characterization, and large-scale structural tests. High-temperature materials to be more completely characterized include advanced coated carbon-carbon and lightweight metals (titanium-aluminide alloys, with and without various fiber-reinforcement systems). The NASP team will complete the instrumentation and thermal/force-loading tests of large-scale components. These components will include wing panels, integrated fuel-tank and fuselage-segment assemblies as well as actively cooled assemblies. Many will be subjected to cycles of loading simulated **X-30** flight conditions. Tests in the latter part of **FY 1993** will provide detailed quantitative results on key flight-critical components and unusual fabrication methods for some of the new materials and structures. Parallel efforts on manufacturing technology will address the challenges of producing consistently high-quality, large-scale supplies of the new materials. Other activities will address adverse effects of cryogenic hydrogen on materials as well as prove the effectiveness of new inspection and maintenance procedures.

The NASP team working on propulsion will complete several tests of large-scale engine models at speeds up to approximately Mach **8** in ground test facilities in **FY 1993**. Such tests will not only prove engine cycle concepts, including those for ramjet-to-scramjet transition, but will also verify component design. Additional work on engine materials and structures, including actively cooled sections, will provide the basis for the detailed **X-30** engine design. Other activities will define the best vehicle systems and handling techniques for slush hydrogen, a cryogenic mixture of both liquid and solid hydrogen (with greater fuel density and heat-sink capacity). As with the airframe tasks, advanced instrumentation and control systems are critical to the integration of the total effort.

The NASP team will complete the basic aerodynamics data base for the new **X-30** configuration over the full operating range (i.e., takeoff to Mach **25**). NASA will conduct much of this experimental and analytic work to produce data on performance, stability, and control. NASA will also complete its contributions to the formation of new aerothermodynamic methodologies, such as those for predicting hypersonic boundary-layer transition. NASA will also contribute key data on powered effects on wind-tunnel testing to guide engine/airframe integration.

Computational fluid dynamics (CFD) will continue to play a vital role in both aerodynamics and propulsion. The CFD tools for NASP, including sophisticated grid manipulation, will be further refined and applied in FY 1993. Such computational tools are essential to yield detailed, three-dimensional characterizations of internal and external flows, especially with non-equilibrium gas chemistry effects that are encountered at flow conditions above Mach 12.

SPACE RESEARCH
AND TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
	(Thousands of Dollars)				
Research and technology base	125,688	141,600	141,800	173,800	RD 14-6
In-Space technology experiments program	11,200	16,000	15,500	--	RD 14-16
Civil space technology initiative (CSTI) program	119,000	114,300	79,800	158,200	RD 14-18
Exploration technology program........	27,500	52,000	29,000	--	RD 14-23
Space automation and telerobotics	(128,534)	82,900	37,900	--	RD 14-25
Exploration mission studies	3,500	15,000	5,000	--	
Total	286,888	421,800	309,000	332,000	

Distribution of Proeram Amount By Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Stennis Space Center	250	--	500	500
Johnson Space Center	14,061	25,300	17,900	14,100
Kennedy Space Center	2,150	4,500	4,200	4,600
Marshall Space Flight Center	55,572	64,600	25,200	27,500
Goddard Space Flight Center	11,153	71,600	17,000	18,500
Jet Propulsion Laboratory	37,145	35,400	44,700	48,800
Ames Research Center......	27,544	34,200	32,400	35,400
Langley Research Center	53,749	63,500	56,400	61,800
Lewis Research Center	51,912	68,400	69,400	75,700
Headquarters	33,352	54,300	41,300	45,100
Total............................	286,888	421,800	309,000	332,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY **SPACE RESEARCH AND TECHNOLOGY**

OBJECTIVES AND JUSTIFICATION

The overall goal of the space research and technology program is o provide advanced, enabling techn logies, validated at a level suitable for user-readiness, for future space missions in order to ensure continued U.S. leadership in space. To achieve this goal, the space research and technology program will continue to support a broad-based activity to advance the state-of-the-art at the concept, subsystem and system level; to develop technical strengths in the engineering disciplines within NASA, industry, and academia; and to perform critical flight experiments in areas where testing in the space environment is necessary for technology development.

Beginning in FY 1993, the space research and technology program has been restructured, consistent with the strategic and programmatic thrusts that the program supports. Prior to this budget submission, the space research and technology budget was managed through five program elements: the Research and Technology Base, the Civil Space Technology Initiative (CSTI), the Exploration Technology Program (ETP), In-Space Technology Experiments (In-STEP), and Space Automation and Telerobotics. These programs supported five mission-oriented thrusts related to space science, transportation, exploration, space station, and breakthrough technologies. Crosswalks for both FY 1992 and FY 1993 from the previous structure to the new structure are enclosed. In addition, the FY 1993 Exploration Mission Studies effort will be addressed in the new Space Exploration office budget statements. The description of the FY 1992 and FY 1993 program is included in the Space Exploration section.

In FY 1993, the space research and technology program will consist of two complementary parts: the Research and Technology (R&T) Base and a focused program, the Civil Space Technology Initiative (CSTI). The R&T Base program will continue to serve as the seedbed for new technologies and capability enhancement. Research will be conducted in critical disciplines, and high-leverage technology advances and concepts will be brought to proof of concept. The In-Space Technology Experiments Program (In-STEP), begun in FY 1990, will be transferred into the R&T Base and will continue to support the development of small flight experiments to conduct research and to validate critical technologies that cannot be accomplished on the ground. The R&T Base program will continue as the fundamental foundation upon which the more highly mission-focused technology efforts are built.

CSTI is being restructured to establish budget elements that are identical to the five strategic thrusts they support -- space science technology, transportation technology, planetary surface technology, space platforms technology, and operations technology. The restructuring will ensure that the space research and technology program is highly responsive to the user community's needs. Under the new structure, CSTI will expand to incorporate research and technology activities formerly supported by the exploration technology and the space automation and telerobotics programs. As a focused program, CSTI will continue to provide specifically for the development of selected technologies at larger scale or higher level of maturity and, as required, in the relevant environment of space, for more effective transfer to the user programs. The advanced technology efforts supported by the restructured CSTI program will significantly enhance current capabilities to access, operate in, and explore space. Moreover, the technology developed by these efforts will reduce mission costs and increase safety and reliability.

CHANGES FROM FY 1992 BUDGET ESTIMATE

A reduction of $102.8 million in the space research and technology program is the net result of Congressional direction (-$113.8 million), and reallocation of funding to transatmospheric research and technology (-$5.3 million), offset by the reassignment of space communications activities from the Office of Space Science and Applications (+$15.3 million) and the composite materials effort from the Office of Space Flight (+$1.0 million).

BASIS OF FY 1993 ESTIMATE

The FY 1993 space research and technology program is a first step towards responding to the strong and continuing consensus that investments in advanced research and technology (R&T) are essential to our future success in space. Most recently, the Advisory Committee on the Future of the U.S. Space Program, chaired by Mr. Norman Augustine, reaffirmed the need for a vigorous investment in space research and technology if the Nation is to maintain leadership in space. The FY 1993 space research and technology program, addressing this concern, has been restructured and revitalized to assure the effective development of the advanced technologies necessary for our nation's future space missions.

In FY 1993, the research and technology base program will continue to serve as the seedbed for new technologies and capability enhancement. Several changes will take place in FY 1993 in the research and technology base. Additional emphasis will be placed on newly emerging high-leverage technologies, including control of space structures, automation and robotics, and life support research activities. The Space Communications Research and Technology program, previously supported by the Office of Space Science and Applications (OSSA), is now funded in the Space Research and Technology Base.

The CSTI program has been restructured to focus on research in five categories: space science, planetary surface, transportation, space platforms and operations. The CSTI is a vital component of **NASA's** Space Research and Technology program, intended to build **NASA's** technical strength and to provide options for high-priority future civil space goals. Over the last few years, expansion of the CSTI program has been constrained. Throughout the program there are key activities that need to be revitalized to keep America at the forefront of research and technology. The CSTI's research efforts are critical to ensure that the capabilities to accomplish future space missions will be available when needed. The following discusses the CSTI program thrusts.

The space science technology thrust is primarily concerned with developing the advanced technologies required for acquiring and processing observations from future space and Earth science missions. Specific space science program areas include science sensing and observatory systems. This thrust includes elements that were formerly part of the CSTI science area. The principal program emphasis will be on creating technology options for the next decade's space science missions, as well as providing the enabling technologies for the pool of missions in the **OSSA** strategic plan beyond the decade. In FY 1993, continuing efforts will be expanded in direct detectors, submillimeter sensing, laser sensing, coolers and cryogenics, and micro-precision controls/structures interactions.

The planetary surface technology thrust, which includes elements that were formerly part of the exploration technology program (initiated in FY 1989), will play an important role in **NASA's** development of a broad set of technologies necessary to enable future solar system exploration missions, including robotic missions to the Moon and Mars, a lunar outpost, and the eventual human exploration of Mars. The planetary surface technology thrust is a prerequisite to future robotic and human planetary surface mission operations. In FY 1993, the ongoing program in surface systems will provide technology required to support the power needs of humans and machines on planetary surfaces such as the Moon and Mars. The human support area will provide the unique technologies required for safe and effective long duration human exploration missions.

The transportation technology thrust is primarily concerned with providing the technology needed for future major transportation improvements. The overall goal of the transportation technology thrust is to develop and validate technologies that will provide new capabilities for current and future space transportation vehicle systems, reduce life-cycle costs, substantially improve safety margins and reliability, and increase system availability. This thrust includes elements that were previously part of the CSTI transportation area and the Exploration Technology transportation program. In FY 1993, additional emphasis also will be placed on facilitating the transfer of these emerging technologies to the commercial space sector through joint or cooperative activities with industry.

The space platforms technology thrust is primarily concerned with providing the technology needed for future space platforms for the following mission classes: unmanned Earth orbiting platforms in low Earth orbit or geosynchronous Earth orbit, manned Earth orbiting platforms (space stations), and deep-space platforms. The overall technology goal is to enhance future science, exploration and commercial missions by providing lightweight, durable, stable, and accurately pointed platforms, and highly efficient platform utilities. Once achieved, these advances will lead to reductions in spacecraft launch weight, reduced life-cycle costs by decreasing on-orbit maintenance and logistics resupply needs and increased lifetime operability. This program includes elements that were in the previous CSTI Operations area.

The goal of the operations technology thrust is to develop and validate technologies to reduce the cost of NASA operations, improve the safety and reliability of those operations and enable new, more complex, activities to be undertaken. It will also provide the high capacity data transfer, storage and processing that is implicit in expanding scientific and exploration endeavors. The thrust will provide technology for NASA users, that may also be applicable to the commercial sector and will support major operational improvements for future robotic and human missions both on the Earth and in space. The Operations thrust includes elements previously in the Space Automation and Telerobotics area as well as the science portion of the previous CSTI Operations area.

BASIS OF FY 1993 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Aerothermodynamics research and technology	13,592	15,400	13,900	14,400
Space energy conversion research and technology	10,868	12,800	12,200	12,600
Propulsion research and technology	14,696	16,700	14,200	14,700
Materials and structures research and technology	19,502	20,900	20,300	23,500
Space flight research and technology	15,135	17,300	15,400	16,000
In-space technology experiments program	(11,200)	(16,000)	(15,500)	16,700
Systems analysis	7,633	7,800	6,200	6,400
University space research	17,054	19,100	17,900	18,600
Information and controls technology ...	22,500	26,400	13,800	21,300
Human support technology	4,708	5,200	7,800	8,100
Space Communications	--	--	20.100	21.500
Total	125.688	141.600	141.800	173.800

OBJECTIVES AND STATUS

The objective of the research and technology base program is to gain a fuller knowledge and understanding of the fundamental aspects of phenomena in critical engineering disciplines. The research and technology base program consists of ten program elements: aerothermodynamics, space energy conversion, propulsion, materials and structures, space flight, in-space technology experiments, systems analysis, information and controls, human support and space communications. In addition, the university space research program, supported by the research and technology base, includes research in critical areas to enhance and broaden the capabilities of the nation's academic community to participate more effectively in the U.S. civil space program. A description of the objectives and status of the elements of the research and technology program follows.

The aerothermodynamics program provides for fundamental understanding and prediction of the detailed aerodynamic and thermodynamic loads experienced by high-speed vehicles during ascent, entry and maneuver in both Earth and other planetary atmospheres. This activity is enabling to the successful development and design of advanced aerospace vehicles and is pursuing the following objectives: (1) development and application of advanced computational methods and numerical techniques covering the entire spectrum of continuum, transitional, and rarefied flows; (2) development of accurate and detailed real-gas chemistry and high-speed turbulent flow models and the efficient integration of these models with standard computational flow codes; (3) establishment of a high-quality ground and flight experimental data base for code validation and verification; *(4)* direct correlation and comparison of computations with available ground and flight data; (5) establishment of a detailed aerothermal loads data base and development of fully integrated analysis techniques; and (6) enhancement of engineering design codes and advanced configuration analysis capability to support rapid evaluation of future vehicle/mission concepts. Progress continues to be made in development of advanced computational fluid dynamics (CFD) codes which incorporate thermochemical nonequilibrium effects and coupled radiation, development of a flight test capability sufficient to validate computational predictions and provide correlation for ground test data bases, and extending the level of sophistication and efficiency of engineering design codes for configuration assessment. A database for characterizing and improving performance of the HL 20 lifting body configuration was developed. A five foot model was tested at Mach .l, a twenty inch model was tested at Mach .3 to Mach *4.6* and a six foot model was tested at Mach *6* and 10. Future plans include completing additional wind tunnel testing, including ascent configuration, and additional simulations of late entry and landing will be conducted.

The objective of the space energy conversion program is to develop technology alternatives that improve performance, reliability, and cost effectiveness of space power both for manned and unmanned space operations, including Earth-orbiting and planetary exploration spacecraft. To meet the challenge, improvements of a factor of two to five and increased life potential are being sought in various solar power generation components, chemical energy conversion systems, energy storage systems, electrical power management and distribution, as well as thermal management systems. For spacecraft photovoltaic and energy storage technologies, the goal is to improve the total system performance enough to permit a 50 percent increase in payload mass, while not increasing the spacecraft overall mass. Progress continues to be made in the successful testing of a solar array that is five to ten times lighter than existing arrays. In addition, in FY 1991, a prismatic cell cover and mini-dome fresnel lens developed by NASA was coupled with a Boeing-developed solar cell to achieve the highest cell efficiency yet which was greater than 300 watts per square meter (a 3 times current technology improvement). Progress also continues to be made in extending the lifetime of nickel-hydrogen batteries and reducing their mass by a factor of two over current technology.

The <u>propulsion</u> program focuses on a number of critical technology areas that will greatly improve our ability to gain access to and operate in space in a much more efficient manner. One focus is on extending our knowledge and understanding of fundamental rocket engine chemical and physical processes to enhance future component designs and to predict component performance and life more accurately. Research efforts in this area emphasize the development of a better understanding of rocket engine combustion, heat transfer and turbomachinery internal fluid and dynamic processes, including predictive modeling. In addition, very high-performance low-thrust electric propulsion systems research addresses technology issues and advanced concepts for electrothermal, electrostatic and electromagnetic propulsion for improved thruster life and performance. Progress continues to be made in several areas. Ion engine discharge chamber erosion rates have been reduced by a factor of ***20*** to 50 compared to existing technology and a hydrogen arcjet was successfully demonstrated between ***5*** to ***24*** kilowatts at specific impulses over ***1400*** seconds. Research on auxiliary propulsion will develop concepts for control of space vehicles. Another area of high potential involves the experimental and analytical evaluation of revolutionary new propulsion concepts and fuels which have the potential to dramatically alter our space transportation capabilities in the next century.

The <u>materials and structures</u> program focuses on extended space durability and environmental effects, lightweight structures for space systems, and technology to enable the development of large space structures and advanced space transportation systems with significant improvements in performance, efficiency, durability, and economy. Major technical areas of emphasis focus on fundamental understanding of the processing, properties and behavior of advanced space materials; development of lightweight space-durable materials; computational methods in chemistry to enable the prediction of physical properties and environmental interactions involving materials under space and reentry conditions; nondestructive measurement science for advanced materials; tribological aspects of materials behavior in the space environment; and the development of a wide variety of metallic, intermetallic, ceramic and carbon-carbon materials for thermal protection systems. Structures technology focuses on the development of erectable and deployable structural concepts; methods for in-space construction, monitoring, and repair of large complex structures; dynamics of flexible structures and vibration suppression; new structural concepts for active cooling of hot structures and cryogenic tanks for advanced Earth-to-orbit rocket propulsion systems, future space transportation vehicles, and orbital transfer vehicles; and efficient analysis and design methodology for advanced space structures, including multidisciplinary analysis and optimization. During the past fiscal year, analysis of the data returned by the Long Duration Exposure Facility (LDEF) has improved the definition of the low earth environment, such as in debris and micrometeoroid modeling, and has proven very valuable in directing the continued development of tailored polymers, advanced metals and composites. In space structures research in-space construction of a large truss was demonstrated advanced fabrication methodology was developed for hot structures; and materials were evaluated for more durable thermal protection systems.

Areas addressed by the information and controls program include computer science, sensors, photonics, controls, guidance, automation and robotics. In the computer science area, the thrusts of the research are in access to and management of very large scientific data sets; software engineering tools for generating very complex and very reliable software; and innovative, and potentially highly effective, computational approaches such as neural networks. The primary objective of the photonics research is to develop opto-electronic components and system concepts to enable high-speed optical sensing and computing. The sensors research area is aimed at novel sensing and electronic devices for high-energy (gamma, x-ray, ultraviolet) observation missions. In the controls area, the goal is to shorten by orders of magnitude the time to compute controls solutions for complex systems. New computational approaches have been developed and are being successfully integrated into advanced computational controls tools. In automation and robotics, research will concentrate on advanced sensors and mechanisms to support telerobotics and the development of advanced concepts in artificial intelligence applicable to the problem sets of interest to NASA.

The space communications program focuses on the development of critical high risk devices, components, and analytical methods that may be used by NASA programs, U.S. industry, and other government agencies. The program contributes to the preservation of U.S. preeminence in satellite communications technology. The advanced research focuses on the areas of microwave and millimeter-wave devices, digital systems development and optical communications. The goal is to develop enabling technologies which are bandwidth and power efficient, have extended lifetimes, and are low in weight and volume. In the radio frequency technology area, continuing advancements in antennas, satellite switching, low noise receivers, and high power amplifiers are being achieved. State-of-the-art performance was demonstrated in a high efficiency, Ka-band traveling wave tube amplifier capable of operating in the deep space environment; radio frequency power and efficiency have been increased by a factor of two compared to current technology. The digital systems technology focuses on the development of high-speed modems and codecs, information and switching processors, and autonomous network control; and in-house computer-aided design facilities are utilized extensively for microprocessor, expert system and neural network applications. The primary objective of the optical communications research is to design, develop, and demonstrate a ground-based high data rate, optical communication terminal for satellite laser crosslinks.

In the human support program, human factors research will provide new technology to model human performance, including physical and cognitive capabilities for use in zero gravity. Extravehicular operations by astronauts will be aided by a new technology in a high-pressure extravehicular glove design and new thermal control methods for life support will be developed. For environmental control and life support systems, the goal is to provide a technology base in chemical processing techniques to support future human space missions. Closed-loop life support chemical processing technologies will provide recycled air and water for crew consumption to eliminate or significantly reduce mission resupply requirements. Progress continues to be made in the development of a set of techniques which collectively are called virtual interactive environment workstation or artificial reality. A data base for virtual exploration of the Mars surface and an earth-analog environment has been established.

The purpose of the space flight research and technology program is to support the flight testing of enabling and enhancing technologies which require the actual space environment for validation. This program encompasses the identification and definition of future in-space flight experiments generated within U.S. industries, universities and the government; the continued design, fabrication, and flight certification of several experiments in preparation for space validation that were initiated prior to FY 1990, including the Light Detection and Ranging In-Space Technology Experiment (LITE); and the development of unique, special purpose experiment hardware systems to facilitate technology validation in the space environment.

The objectives of the systems analysis program are to identify critical technologies for key future mission concepts and technology opportunities for enabling new and improved future mission possibilities, to integrate these into a comprehensive set of technology planning options, and to generate candidate plans to develop these technologies in a timely manner. This effort is closely coordinated with the spaceflight mission program offices to identify the technology requirements for their future mission concepts and technology opportunities for enabling new and improved mission approaches. Progress continues to be made in defining the critical technologies associated with earth science observations for understanding global change and on defining technologies for future astrophysics missions beyond the Great Observatories; the identification of high priority technologies which will increase reliability and reduce operations cost for the current shuttle system (shuttle evolution), developments for future unmanned launch vehicles; and second generation manned vehicles. Work will also be performed to determine the technology needs in support of operation of NASA missions in the 21st century.

The objective of the university space research program is to enhance and broaden the capabilities of the nations' engineering community to participate more effectively in the U.S. civil space program. This program is an integral part of the strategy to strengthen the nation's space research and technology base. This program elements include the university space engineering research center program, which supports interdisciplinary research centers at nine universities; the university innovative research program, which provides grants to individuals with outstanding credentials; and the university advanced space design program, which funds senior level advanced systems study courses. Significant technical, research and educational benefits have begun to be demonstrated from the university space engineering research centers, including attracting, retaining, and training graduate students and increased industry support.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The research and technology base has increased by $0.2 million. This is the net effect of a $16.0 million general reduction directed by Congress and a $15.3 million reassignment discussed below. The reduction, which includes $10.5 million previously earmarked for acquisition of laboratory equipment and $5.5 million for research activities, will be accommodated across the program. Reassignment of $15.3 million for communications technology development from the Office of Space Science and Applications and $1.0 million for carbon-carbon composite structures studies from the Office of Space Flight were also made. In addition, $0.1 million was reallocated to the Transatmospheric research and technology program reducing hypersonic research efforts in the Space R&T Base.

The changes by the discipline programs are as follows:

The aerothermodvnamics program has been reduced by $1.5 million. This change reflects a Congressional reduction of $1.9 million which has been offset by an increase of $0.4 million from information and controls research and technology for configuration analysis.

The space energy conversion program has been reduced by $0.6 million, consisting of a $1.8 million Congressional reduction offset by a realignment of $1.2 million from the information and controls research and technology program to support power management.

The current estimate of the propulsion program reflects a net reduction of $2.5 million, $2.0 million resulting from Congressional action and a general reduction of $0.5 million for the development of advanced life support in human support research and technology.

The materials and structures program reflects a reduction of $0.6 million. This reduction consists of $2.0 million resulting from Congressional action and a reallocation of $0.1 million from hypersonic research activities to the Transatmospheric research and technology program. These reductions were offset by the reassignment of $1.0 million from the Office of Space Flight for carbon-carbon composite structures and the realignment of $0.5 million from the information and controls program to support tribiology efforts.

The space flight program has been reduced by a total of $1.9 million, consisting of $1.7 million to accommodate Congressional direction and $0.2 million which was realigned to the human support technology program for the development of advanced life support technologies.

The systems analvsis program reduction of $1.6 million includes a realignment of $0.2 million to the human support technology program for the development of advanced life support technologies and a decrease of $1.4 million to accommodate Congressional direction.

The university space research program has been reduced by a total of $1.2 million. This includes an $0.4 million realignment to the human support technology program for the development of advanced life support technologies and a reduction of $0.8 million to accommodate Congressional direction.

The information and controls program reflects a reduction of $12.6 million. This reduction consists of a $4.2 million reduction resulting from Congressional action, $1.5 million realigned to the human support technology program for the development of advanced life support technologies, realignment of $1.2 million to the space energy conversion to support power management, realignment of **$0.5** million to the materials and structures program to support tribiology efforts, realignment of $0.4 million to the aerothermodynamics program to support configuration analysis, and realignment of communications research ($4.8 million) into the newly established space communications program. The reductions to the information and controls program will impact virtually all elements of the program and will delay ongoing and planned research activities.

The **human support research and technology** program reflects an increase of $2.6 million. This increase consists of a $0.2 million reduction resulting from Congressional action, offset by realignments from the following programs for the development of advanced life support technologies: $0.5 million from the propulsion program, $0.2 million from the space flight program, $0.2 million from the systems analysis program, $0.4 million from the university space research program, and $1.5 million from the information and controls program.

The **space communications** research and technology program has been established in FY 1992. It includes $15.3 million, which was reassigned from the Office of Space Science and Applications, as well as $4.8 million of communications activities which were realigned from the information and controls program within the space research and technology base.

BASIS OF FY 1993 ESTIMATE

In FY 1993, the **aerothermodynamics** program emphasis will center on developing an improved understanding of chemical and radiative nonequilibrium flow phenomena and on low density flows. This physical understanding is critical to improving the computational design tools necessary to reduce vehicle design risk and uncertainties.

The FY 1993 **space energy conversion** program is directed toward four areas: The first is photovoltaic power technology which will continue to focus on improving solar cell efficiency, while reducing solar cell degradation and weight, and developing lighter weight solar arrays. The second is battery storage technology which will focus on improving the energy density and the life of the batteries by at least a factor of five (from approximately 20 watt-hours per kilogram). The third area is concerned with several approaches to improve the efficiency of converting thermal energy into electrical power. These approaches include higher efficiency thermoelectric materials, the advanced (threefold improvement over current state-of-the-art) alkali metal thermoelectric conversion system, and improved solar dynamic power systems. The fourth area is power management technology which will emphasize the development of lightweight, high-temperature, radiation-hardened and fault-tolerant power components and systems.

In FY 1993, the **propulsion** program will continue to support technology efforts that will enhance our ability to gain access to and operate in space in a much more efficient manner. These include the development of a better understanding of rocket engine combustion stability and turbomachinery internal fluid and dynamic processes, and the development of the fundamental understanding necessary for long-term storage, transfer and maintenance of cryogenic propellants in space. Research on auxiliary propulsion will develop concepts for control of space vehicles. Beyond these more classical propulsion systems lies the potential for higher energy systems, such as fission, fusion, etc., which in the far future could provide high-thrust propulsion systems with capabilities much beyond those which are currently possible. Studies are being conducted to evaluate the potential of turning these high-energy sources into practical propulsion systems and identifying critical technology issues that need to be pursued.

In FY **1993** the materials and structures program will continue to focus on extended space durability and environmental effects, lightweight structures for space systems, and technology to enable the development of large space structures. Continued evaluation of materials and coating systems on board the Long-Duration Exposure Facility **(LDEF)** will provide a baseline for assessing stability and long-term durability of materials, coatings, solar cells and other related space systems in both low Earth orbit and geosynchronous Earth orbit. This activity should be completed by FY **1995.** Individual and synergistic space environmental effects (such as radiation and atomic oxygen effects) on materials will be assessed using degradation models to describe environmental interaction. **A** space-rigidizeable polymer and composite system will be demonstrated in **FY 1993** for in-space fabrication of structures. Computational chemistry will be used to model material interaction phenomena on the molecular level. Advanced materials and structural concepts will be explored for integral cryogenic tanks and thermal protection systems, including advanced metallic and composite cryogenic tank concepts and durable, woven ceramic thermal protection systems, for future space vehicles. Development of methods for in-space construction including ground-based robotic assembly of complex platforms and structural components will be accomplished, and techniques for on-orbit fabrication and joining of structural elements will be investigated. Some research elements of the controls/structures interaction (CSI) program, previously supported by the CSTI program, will be transferred into the R&T Base in **FY 1993.** These activities will focus on analytical and ground-testing methodology for control, pointing, and vibration reduction of large interferometer-like structures; space platforms for earth or space observations; and long truss-like structures for space observations or support structures.

The **FY 1993** information and controls program supports applied research in computer science, sensors, photonics, controls, guidance, automation, and robotics. In the computer science area, the focus is continuing on access to and management of very large scientific data sets; software engineering tools for generating very complex and very reliable software; and innovative, but potentially highly effective, computational approaches such as neural networks. Sensor research will continue to concentrate on development of solid-state laser materials for enhanced atmospheric science, ranging and altimetry, and other remote sensing applications. Photonic research will emphasize device development in opto-electronic integrated circuit technology for spaceborne systems, such as autonomous landing and optical computing. In **FY 1993,** some research efforts in automation and robotics will be transferred from the space automation and telerobotics program into the **R&T** Base. Artificial intelligence efforts will include machine learning, distributed diagnostic systems capable of model based, as well as experimental reasoning, and embedded real-time systems for scheduling, control and diagnostics. In telerobotics, the program will support academic research on mobile planetary robotic systems, free-flying telerobotic systems and multiple interactive robotic systems. In the controls and guidance area, emphasis is being placed on the development of analytical tools for the design of control systems for precision pointing and control of large flexible spacecraft and for avionics systems technology for advanced transportation vehicles.

In FY 1993, the space communications program, a new element added to the R&T Base in FY 1992, will be directed toward NASA and commercial satellite communications needs. The commercial satellite communications technology program was previously contained within the Office of Space Science and Applications budget. This program supports applied research and advanced developments in the areas of digital technology, optical, communications and radio frequency communications. The digital technology area emphasizes research on modulation, coding, and switching up to 1 gigabit per second. The optical communications area is advancing the state-of-the-art in laser transceivers for free-space optical communications. The radio frequency communications area is performing research on high-efficiency monolithic millimeter-wave circuit technology on high-performance electron beam technology for advanced deep-space and satellite communications. Additionally, high-temperature superconductor microwave circuits are being developed for a joint experiment with the Naval Research Laboratory. Components for a low-noise receiver/downconverter subsystem are in development to test the validity and reliability of these devices in space.

In FY 1993 the human support program, human factors research will continue development of new technology to model and enhance human performance. Models and data on physical and cognitive capabilities in microgravity will be emphasized. Particular focus will be placed on new methods of presenting visual information via computer-based displays and technology to visualize virtual environments for planetary surface applications. Extravehicular operations by astronauts will be aided by research on concepts for a high-pressure extravehicular glove, and new thermal control methods for life support will be supported. Research on closed life support chemical processing technologies will provide recycled air and water for crew consumption to eliminate or significantly reduce mission resupply requirements.

In FY 1993, the in-space technology experiments program (In-STEP) will be transferred into the research and technology base. As discussed above, the transfer of this program will provide more flexibility in determining the experiment feasibility, definition, and development of the hardware/software for the space validation of new technologies. The experiments will be aligned along the major space technology thrusts providing a clear link between the base research within the NASA Centers and JPL, U.S. industries and universities, and major space systems development. Both this effort and the FY 1993 space flight research and technology program will support the flight testing of enabling and enhancing technologies which require the actual space environment for validation. Flight data obtained from in-space research and experimentation will be used to validate and verify analytical models, prediction techniques, and ground test methods and facilities. Both efforts will support the identification, definition, design, fabrication, and flight certification of future in-space flight experiments. These experiments will utilize the Space Shuttle, Expendable Launch Vehicles, and Space Station Freedom as platforms to validate these new and innovative technologies. The space flight research and technology program will focus on supporting experiments identified by NASA Centers and the Jet Propulsion Laboratory. The in-space technology experiments element will continue to support technology flight experiments generated within U.S. industries and universities. Specifically, in the space flight experiments effort, three experiments are currently in development, two experiments are in definition and several more NASA experiments will be selected for feasibility studies as part of the FY 1992 Announcement of Opportunity. In the in-space technology experiments program, five experiments are currently in development, thirteen experiments are in definition, two experiments are undergoing feasibility studies, and a group of new industry/university experiments will be selected for feasibility studies as part of the Announcement of Opportunity. In FY 1992, two in-space technology experiments (the Heat Pipe Performance experiment and the Environmental Verification experiment for the Explorer Platform) are scheduled to fly on the Space Shuttle.

The systems analysis program supports the development of analytic tools and data bases required to perform engineering tradeoff studies in order to prioritize and integrate multidisciplinary sets of technology options. This effort is closely coordinated with the spaceflight mission program offices to identify the technology requirements for their future mission concepts and technology opportunities for enabling new and improved mission approaches for space platforms, space transportation, operations and science spacecraft. The FY 1993 activities will include analysis of Space Station Freedom facilities to assess their suitability as an in-space laboratory for engineering research and validation of technologies required for space exploration, space science, and transportation. In addition, the relative impacts of the various technologies on space platform performance will be analyzed. Also, in FY 1993, emphasis will be placed on launch vehicle concept design studies to assess technologies for the next generation of manned launch vehicles and nuclear electric propulsion for cargo and piloted space transfer vehicles. Technology options to be studied address staged and single-stage-to-orbit vehicles, horizontal and vertical takeoff and landing vehicles, rocket and airbreathing vehicles, and combined engine concepts. Other efforts will focus on conducting studies on technologies for the next generation of astrophysics observatories, understanding the potential microspacecraft and micro-science instruments for future earth and planetary science, and studying the critical technologies necessary for enabling the projected data rates of future science missions. Finally, analysis will be undertaken to determine technology needs for future mission control activities, and to support ground test and processing of space vehicles.

In the FY 1993, university space research program support will continue for the three program elements: the university innovative research program, which provides grants to individuals with outstanding credentials; the university advanced space design program, which funds advanced systems study courses at the senior level; and the university space engineering research center program, which supports interdisciplinary research centers. In FY 1993, emphasis will be applied to maintaining the nine incumbent university space engineering research centers at their planned funding level.

BASIS OF FY 1993 FUNDING REQUIREMENT

IN-SPACE TECHNOLOGY EXPERIMENTS PROGRAM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
In-space technology experiments program	11,200	16,000	15,500	--*

* Transferred into the Research and Technology Base.

OBJECTIVES AND STATUS

The purpose of the in-space technology experiments program (IN-STEP) is to develop key flight experiments which will provide validated, advanced space technologies offering major improvements in the effectiveness and efficiency of future space systems. Previous efforts in the research and technology base have identified and defined advanced technology concepts that require testing or validation in the actual space environment in order to reduce the risk to potential applications and to increase the rate of transfer of advanced technologies into future space missions. The IN-STEP program supports the development of the flight hardware from defined flight experiments. The two major elements of this program are the NASA experiments and industry/university experiments.

In FY 1991, the first two experiments supported by the In-Space Technology Program were flown successfully on the Space Shuttle, the Middeck Zero-Gravity Dynamics Experiment (MODE) and the Tank Pressure Control Experiment (TPC). The goal of the TPC experiment was to validate predicted mixing and thermal stratification characteristics of fluids in a zero-gravity environment influenced by jet-induced flow. The goal of the MODE was to provide basic information on the dynamics of fluids and structures in microgravity thereby reducing the risk for large systems. Data from these experiments, collected on the 1991 Shuttle flights, may significantly reduce cost and complexity of fluid tanks in future spacecraft. In addition, feasibility studies for two experiments continued, thirteen of the experiments continued to be supported in design definition, and nine of the experiments continued to be developed for future flight on the Space Shuttle.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The in-space technology experiments program reflects a $0.5 million reallocation to the Transatmospheric research and technology program, resulting in delays in feasibility studies for proposed in-space flight experiments designed to demonstrate user-based space technologies.

BASIS OF FY 1993 BUDGET ESTIMATE

In FY 1993, this program has been transferred into the research and technology base and will focus on supporting technology flight experiments that have been selected from Announcements of Opportunity, which solicited industry and university space technology flight experiment proposals.

BASIS OF FY 1993 FUNDING REQUIREMENTS

CIVIL SPACE TECHNOLOGY INITIATIVE (CSTI) PROGRAM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Operations	21,803	32,400	33,400	--
Transportation	56,760	63,500	28,000	
Science	18,203	18,400	18,400	--
Automation and robotics	22,234	--	--	--
Space science technology	--	--	--	36,700
Planetary surface technology	--	--	--	22,000
Transportation technology	--	--	--	42,400
Space platforms technology	--	--	--	24,600
Operations technology	--	--	--	32,500
Total	119,000	114,300	79,800	158,200

OBJECTIVES AND STATUS

In FY 1993 the Civil Space Technology Initiative (CSTI) has been restructured to more clearly address the technology needs for high priority civil space missions. It will include all the elements of the ongoing CSTI, Exploration Technology, and Space Automation and Telerobotics programs. The following paragraph discuss the current FY 1992 program. The restructured program is discussed under Basis of FY 1993 Estimates.

The goal of the operations area is to develop and validate technologies to reduce the cost of NASA operations; improve the safety and reliability of those operations; and enable new, more complex, activities to be undertaken. For the ongoing FY 1992 program, specific areas include three elements: (1) control/structures interaction, (2) solar dynamics, and (3) high capacity power. Ongoing efforts include the control/structures interaction (CSI) program, and the solar dynamics program. The controls/structures interaction effort is focused on advancing state-of-the-art technologies to enable the precision control of future space structures that support sensitive science instruments. Another goal of this program is to focus on the control requirements of future manned space stations. In the control/structure interaction area, support continued for developing methods to design, analyze, and test lightweight, high-performance controlled structures. Initial ground-test experimental results indicate an increase in damping results on a factor of 500 jitter reduction for 20-80 meter antennas. The solar dynamics program is working toward the ground demonstration of a 2-kilowatt integrated solar dynamic system. The high-capacity power program will provide the technology for advanced energy conversion components necessary to achieve significant improvements in the power generation capability and power-to-weight ratio of the SP-100 space nuclear reactor concept.

The transportation area has primarily been concerned with providing the technology needed for future major transportation improvements. The overall goal of the transportation technology thrust is to develop and validate technologies that will substantially improve safety margins and reliability, increase system availability, reduce life-cycle costs, and provide new capabilities for current and future space transportation vehicle systems. In FY 1993, additional emphasis also will be placed on facilitating the transfer of these emerging technologies to the commercial space sector through cooperative activities with industry. The transportation area consists of one major element, Earth-to-orbit (ETO) technology. The ETO area includes research on propulsion system component and subsystem technologies, integrated health monitoring/condition monitoring technologies, design tools, and low-cost manufacturing processes for the next generation of expendable and reusable space transportation systems. In FY 1991, several advanced manufacturing technologies were developed and verified, including an advanced casting jacket and two improved combustion liner methods (vacuum plasma spray and formed platelet). These manufacturing technology improvements will result in a readily inspectable and certifiable main combustion chamber which will significantly reduce fabrication costs and production time. In addition, computational fluid dynamics (CFD) analysis of a two-stage generic gas generator turbine design enabled the design of a single stage, rather than a two-stage turbine, which is estimated to increase efficiency by 10 percent, reduce blade count by 55 percent and ensure significant reductions in life cycle costs.

The science area has primarily been concerned with providing the technology needed for future space science missions. The current program consists of two elements, science sensor and the high rate/capacity data systems, both of which will have their primary application in the Earth Observing System (EOS): direct detectors, submillimeter sensing, laser sensing, and coolers and cryogenics. Two efforts will develop infrared detector arrays to enable long wavelength observations and solid-state laser system components. The sensors can be characterized as having significantly increased sensitivity, resolution, and/or longer life than those previously available. The coolers and cryogenics program involves the development of a Stirling cooler capable of cooling detectors to 30 degrees Kelvin. These coolers will provide high reliability and low vibration to enable measurements of global warming, ozone depletion and other large-scale phenomena. In FY 1991, accomplishments include demonstrating high sensitivity and spectral response on two 1 by 270 mercury zinc telluride linear arrays. These arrays were vacuum baked for 26 days at 100 degrees centigrade and showed no degradation in responsivity. The high rate data systems area addresses the high-priority needs across NASA for more capable space processors and systems, more effective software development, and advanced communications capabilities. In particular, the program will concentrate on space-qualifiable computers, special processors, and memory systems, and will investigate architectures to support space data systems. In FY 1991, the high rate/capacity data area, support for a general purpose, very high speed lossless data compression/decompression chip set for science spacecraft application was continued. A chip set that consumes 0.4 watts, adapts to optimized data work to information content, is capable of varying data densities and has embedded data symbols was developed. This chip set will enable increased onboard storage or an increase of telemetry bandwidth by a factor of two. The Office of Space Science and Applications plans to use this chip set to increase the onboard storage capacity for the Hubble Space Telescope. Also under the observatory systems area is micro-precision controls/structures interaction, which will focus on submicron vibration suppression and structural dynamic and stabilization.

CHANGES FROM FY 1992 BUDGET ESTIMATE

In total, funding for CSTI is reduced $34.5 million. The CSTI operations area reflects an increase of $1.0 million. This is the net effect of a reallocation of $4.0 million ($3.7 from high-capacity power and $0.3 million from controls/structures interactions) to the Transatmospheric research and technology program, which has been offset by the increase of $5.0 million for solar dynamics activities as a result of Congressional action on the FY 1992 budget request. The reductions in the operations area will result in significant delays of research activities and the termination of some contracted efforts.

A decrease of $35.5 million is shown in the CSTI transportation area. This reflects the termination of the aeroassist flight experiment ($34.8 million) in accordance with Congressional direction and a reduction of $0.7 million in the earth-to-orbit propulsion program for reallocation to Transatmospheric research and technology. The earth-to-orbit propulsion reduction will result in the delay of some activities.

BASIS OF FY 1993 ESTIMATE

In FY 1993 the CSTI program has been restructured to more clearly address the technology needs for high priority civil space missions and will focus on research in five thrust areas: space science, planetary surface, transportation, space platforms and operations. The CSTI program incorporates elements of the previous Exploration Technology program (initiated in FY 1989) and the Space Automation and Telerobotics program (initiated in FY 1992). The CSTI program will support many critical technology efforts that are essential to accomplishing NASA's future space goals and will contribute to ensuring U.S. preeminence in research and technology. The following discusses the CSTI program thrusts. Crosswalks for both FY 1992 and FY 1993 from the old structure to the new structure are enclosed.

In the space science technology thrust, the science sensor technology activities in FY 1993 will continue to be based on development of detectors in the 4- to 17-microns region using multiple quantum-well and mercury zinc telluride devices, in the 30- to 300-microns region using blocked impurity band phenomena, and in the submillimeter wave region on quantum-well local oscillator and superconducting tunnel junction mixers. A solid-state laser technology for light detection and ranging (LIDAR) applications will continue to be developed. In addition, the science sensor technology element will include support for the development of advanced mechanical coolers and infrared detectors with performance and lifetime characteristics required by future Earth observing missions. Micro-precision control/structures interaction technology will continue to focus on nanometer structural control for a space-based interferometer.

In the **planetary surface technology** thrust, the surface systems program area will continue to support research such as space nuclear power, focused on component technology for refractory metal reactors, solid-state thermoelectric conversion, and thermal management technologies such as heat pipes. NASA's participation in the multi-agency SP-100 space nuclear power program is supported through this effort. The high-capacity power program will continue to focus on fabricating and testing a Stirling engine at 1050 degrees Kelvin. Plans for activities related to space nuclear reactor power systems will be updated this spring after completion of an Administration review of potential applications, technology options, and cost/schedule factors. The human support program area will address the technology for improving astronaut productivity, maintenance, and health, with minimal or no dependence on resupply of expendables for life support. Research will continue in regenerative life support systems technology, including air revitalization, water reclamation, and environmental monitoring and control; extravehicular activity suits, including highly-dexterous, high-pressure gloves, suit end effectors and tools for planetary surfaces; portable life support systems, including thermal management systems and carbon dioxide removal; and radiation protection technology, including the development of radiation transport computer models and radiation protection shielding materials and structures.

In the transportation technology thrust, research will continue on earth-to-orbit transportation and space transportation programs. In FY 1993, the earth-to-orbit propulsion program will focus on technology validation testing in each of three major areas: combustion devices, turbomachinery, and systems and controls monitoring. New technology efforts in these areas will play a key role in significantly reducing the costs of access to space. The technologies included in the space transportation program area are related to timely and cost-effective transportation to and from the Moon and Mars, for both piloted and robotic exploration missions. Research will continue in areas such as cryogenic hydrogen-oxygen engines for space transfer vehicles and for ascent/descent propulsion, including a breadboard testbed engine and technology for high throttleability, long life, multiple restarts, integrated engine diagnostics and controls, and for engine space-basing and servicing. The technology developed in the nuclear propulsion program area will address multiple approaches to applying space nuclear propulsion systems to the improvement of mission performance for human missions to Mars. Research efforts will include solid core nuclear system concepts, capable of long-life and multiple starts, and nuclear electric propulsion technologies, including magnetoplasmadynamic (MPD) thrusters for a future human mission to Mars application. In FY 1993, a new effort will include technologies to support low-cost transport. This activity will focus on propulsion and vehicle system technologies that are of special interest for both government and commercial activities. These efforts will include low-pressure, passively cooled propulsion for booster applications, low-cost engine manufacturing techniques, cost-effective structural materials, and vehicle health management technologies. New technology efforts in these areas will play a key role in significantly reducing the costs of access to space.

In the space platforms technology thrust, platform structures and dynamics will focus on developing and applying controls/ structures interaction techniques to space platforms and to developing advanced platform structures concepts. Ground-based hardware testbeds, including both in-house and non-NASA guest investigator activities, will continue to be supported. The platform power and thermal systems will focus on developing and demonstrating key technologies for increased power at reduced costs for future Earth-orbiting spacecraft, including Space Station Freedom, low earth orbit (LEO), or geostationary earth orbit (GEO) science spacecraft, and future astrophysics missions. In FY 1993, the research focus will be on developing a 2-kilowatt ground test of a solar dynamics-based power system.

In the operations technology thrust, the FY 1993 program will focus on supporting automation and robotics and space data systems. The automation and robotics portion will focus on advanced teleoperation, robotics and supervisory control (telerobotics) to be applied to problems in launch processing, on-orbit operations and processing, and science operations. The artificial intelligence program will focus on providing real-time, fault-tolerant control for flight critical systems and on developing, testing and validating increasingly complex autonomous systems, starting with automation of a single critical function and progressing to coordinated control of multiple critical functions. The Space data systems efforts will continue to focus on developing and demonstrating new onboard processing and data storage capabilities for a range of future space and Earth science, exploration and infrastructure systems. In FY 1993, this effort will continue development of a brassboard space flight optical disk recorder module. Preliminary design of experimental onboard digital processors and correlators will be continued. This includes increasingly productive assistance to mission operations, moving from single function applications toward multiple, cooperating applications, automated engineering analysis tools, autonomous on-board diagnostic systems and life-cycle knowledge capture systems.

BASIS OF FY 1993 FUNDING REQUIREMENT

EXPLORATION TECHNOLOGY PROGRAM

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Space transportation	5,850	9,000	5,000	--
In-space operations	1,975	--	--	--
Surface operations	13,623	20,000	12,000	--
Human support	3,827	16,000	7,000	--
Lunar and mars science	650	--	--	--
Nuclear propulsion	500	7,000	5,000	--
Innovative technologies and systems analysis	1,075	--	--	--
Total	27,500	52,000	29,000	--

OBJECTIVES AND STATUS

In FY 1993, the Exploration Technology program has been transferred into the two thrusts of the restructured CSTI, planetary surface technology and transportation technology. The following addresses the current ongoing. FY 1992 program. The exploration technology program is an activity that develops a broad set of technologies to future decisions on and development of future space exploration missions. The exploration technology program is a focused technology program that will strengthen the technological foundation of the civil space program and the nation's leadership to go forward with ambitious future human and robotic solar system exploration missions. In FY 1992, this program will support four technology areas: space transportation, surface operations, human support, and nuclear propulsion.

The technologies included in the space transportation program area are related to timely and cost-effective transportation to and from the Moon and Mars, for both piloted and robotic exploration missions. The surface operations program area is developing technologies for advanced planetary operations, such as space nuclear power. Significant accomplishments in FY 1991 include achieving full burn-up with prototypic fuel in representative fuel pins, completing fuel pin design and fabrication process (which included demonstrating bonding of the fuel pins to the rhenium liner), completing 50 percent of the reactor ground test facility/cell design, demonstrating successful forming and welding of key reactor structures, and successful development and tests of thermoelectric cell components (insulators, compliant pads and electrodes). The human support program area addresses the technology for improving astronaut productivity, maintenance, and health, with minimal or no dependence on resupply of expendables for life support. The technology developed in the nuclear propulsion program area addresses multiple approaches to applying space nuclear propulsion systems to the improvement of mission performance for human missions to Mars.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The exploration technology program has been reduced by a total of $23.0 million. This is the net effect of Congressional action which reduced the program by $25.0 million and provided an additional $2.0 million for laser power beaming research. In the space transportation area, advanced cryogenic engine research was reduced by $4.0 million. In the surface operations area space nuclear power (SP-100) was reduced by $10.0 million, and an additional $2.0 million was provided for laser power beaming research. The reduction in the human support area totaled $9.0 million ($4.5 million in regenerative life support technology; $1.5 million in radiation protection; $2.0 million in extravehicular activity systems; and $1.0 million in exploration human factors). The nuclear propulsion area was decreased by $2.0 million ($1.5 million in nuclear thermal propulsion and $0.5 million in nuclear electric propulsion). These reductions will result in delays, replanning, and stretchout of various elements of the program.

BASIS OF FY 1993 ESTIMATE

In FY 1993, the exploration technology program has been transferred into the two thrusts of the restructured civil space technology initiative, planetary surfaces technology and transportation technology. The planetary surface thrust will continue to support human support technology efforts as well as multi-agency space nuclear power activities, for which specific plans will be finalized after an Administration review this spring. 'The transportation thrust will continue to support the technology efforts in advanced cryogenic engines and nuclear propulsion.

BASIS OF FY 1993 FUNDING REQUIREMENT

SPACE AUTOMATION AND TELEROBOTICS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Flight telerobotic servicer	(106,300)	55,000	--	--
Telerobotics	(11,538)	14,800	24,800	--
Artificial Intelligence	(10,696)	13,100	13,100	--
Total	(128,534)	82,900	37,900	--

OBJECTIVES AND STATUS

In FY 1993, the majority of the telerobotics and artifical intelligence elements have been transferred into the Civil Space Technology Initiative operations technology thrust. The following discusses the FY 1992 program. In FY 1992, the Space Automation and Telerobotics program consisted of three elements, the technology portion of the flight telerobotic servicer (FTS), telerobotics technology efforts and artificial intelligence technology efforts. In FY 1992, it was planned to continue development of the first FTS Development Test Flight, DTF-1. The goal of the telerobotics element is to integrate and demonstrate technology for space telerobotics to enhance operational capability and decrease cost of space operations. The program focuses on advanced teleoperation, robotics and supervisory control (telerobotics). The goal of the artificial intelligence program is to exploit artificial intelligence for control of multiple subsystems with the capability for automated reasoning and recovery from unanticipated failure. This technology effort will focus on providing real-time, fault-tolerant control for flight critical systems and on developing, testing and validating increasingly complex autonomous systems, starting with automation of a single critical function and progressing to coordinated control of multiple critical functions. The application of this technology to future exploration, space station, space shuttle and space science missions will result in higher degrees of onboard autonomy and reduction in manpower required in mission control. This technology will enable increased safety and likelihood of mission success by permitting more intelligent control and warning systems and by permitting the onboard system to dynamically replan around existing failures.

CHANGES FROM FY 1992 BUDGET ESTIMATE

This program was reduced by $45.0 million, which reflects the termination of the flight telerobotic servicer program ($55.0 million) as directed by Congress, with $10.0 million redirected to the telerobotics program for advanced competitive robotics efforts.

BASIS OF FY 1993 BUDGET ESTIMATE

In FY 1993, the majority of the telerobotics and artificial intelligence elements have been transferred into the civil space technology initiative operations technology thrust. In addition, base like efforts have been transferred into the R&T base.

FY 1992 SPACE R&T CROSSWALK

(M)

NEW STRUCTURE		SPACE R&T BASE	IN-SPACE TECH. EXPERIMENTS	CIVIL SPACE TECH. INIT.	OPERATIONS	TRANSPORTATION	SCIENCE	EXPLORATION TECH.	SPACE TRANSPORTATION	IN-SPACE OPERATIONS	SURFACE OPERATIONS	HUMAN SUPPORT	NUCLEAR PROPULSION	SPACE AUTOMATION AND TELEROBOTICS	EXPLORATION MISSION STUDIES
		PREVIOUS STRUCTURE													
SPACE RESEARCH AND TECHNOLOGY	309.0	141.8	15.5	79.8	33.4	28.0	18.4	29.0	5.0	-	12.0	7.0	5.0	37.9	5.0
SPACE R&T BASE	157.3	141.8	15.5	-	-	-	-	-	-	-	-	-	-	-	-
CIVIL SPACE TECHNOLOGY INITIATIVE	151.7	-	-	79.8	33.4	28.0	18.4	29.0	5.0	-	12.0	7.0	5.0	37.9	5.0
SPACE SCIENCE TECHNOLOGY	13.5	-	-	13.5	-	-	13.5	-	-	-	-	-	-	-	-
PLANETARY SURFACE TECHNOLOGY	30[illegible]	-	-	6.9	6.9	-	-	19.0	-	-	12.0	7.0	-	-	5.0
TRANSPORTATION TECHNOLOGY	38.0	-	-	28.0	-	28.0	-	10.0	5.0	-	-	-	5.0	-	-
SPACE PLATFORMS TECHNOLOGY	26.5	-	-	26.5	26.5	-	-	-	-	-	-	-	-	-	-
OPERATIONS TECHNOLOGY	42.8	-	-	4.9	-	-	4.9	-	-	-	-	-	-	37.9	-

FY 1993 SPACE R&T CROSSWALK

($,M)

PREVIOUS STRUCTURE

NEW STRUCTURE

NEW STRUCTURE		SPACE RESEARCH & TECH.	SPACE R&T BASE	IN-SPACE TECH. EXPERIMENTS	CIVIL SPACE TECH. INIT.	OPERATIONS	TRANSPORTATION	SCIENCE	EXPLORATION TECH.	SPACE TRANSPORTATION	SURFACE OPERATIONS	HUMAN SUPPORT	NUCLEAR PROPULSION	SPACE AUTOMATION AND TELEROBOTICS
		[illegible]	157.1	16.7	108.7	33.7	32.4	[illegible]	[illegible]	[illegible]	[illegible]	7.0	5.0	[illegible]
SPACE RESEARCH & TECH.	332.0													
SPACE R&T BASE	173.8		157.1	16.7		-	-	-	-	-	-	-	-	-
CIVIL SPACE TECHNOLOGY INITIATIVE	158.2		-	-	108.7				27.0					22.5
SPACE SCIENCE TECHNOLOGY	36.7		-	-	36.7	4.1	-	32.6	-	-	-	-	-	-
PLANETARY SURFACE TECHNOLOGY	[illegible]		-	-	5.0	5.0	-	-	17.0	-	10.0	7.0	-	-
TRANSPORTATION TECHNOLOGY	42.4		-	-	32.4	-	32.4	-	10.0	5.0	-	-	5.0	-
SPACE PLATFORMS TECHNOLOGY	24.6		-	-	24.6	24.6	-	-	-	-	-	-	-	-
OPERATIONS TECHNOLOGY	32.5		-	-	10.0	-	-	10.0	-	-	-	-	-	22.5

SPACE EXPLORATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF EXPLORATION

SPACE EXPLORATION

SUMMARY OF RESOURCES REOUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Exploration mission studies	(3,500)	(15,000)	(5,000)	3,000	RD 15-3
Exploration precursor missions	--	--	--	28,800	RD 15-5
Total	(3,500)*	(15,000)*	(5,000)*	31,800	

* Budgeted under Space Research and Technology

Distribution of Proeram Amount BV Installation

	1991	1992 Budget	1992 Current	1993
Johnson Space Center....	--	--	--	15,300
Headquarters	--	--	--	16,500
Total	--	--	--	31,800

OFFICE OF EXPLORATION **SPACE EXPLORATION**

In December 1990, and again in May 1991, two study groups, the Augustine Committee and the Synthesis Group recommended that a separate program office be established for Space Exploration, and that an Associate Administrator be appointed to head up this program. In October 1991, the Office of Exploration was established, and an Associate Administrator appointed.

Exploration Mission Studies requirements were formerly budgeted under Space Research and Technology. However, since the new Office of Exploration acquired management responsibility for FY 1991 and FY 1992 funding is shown here for continuity. The FY 1993 request provides for continued emphasis on the identification of required technologies and includes a new budget element to develop and conduct several small-scale, robotic/automated precursor missions.

BASIS OF FY 1993 FUNDING REQUIREMENT

SPACE EXPLORATION

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Exploration mission studies	(3,500)	(15,000)	(5,000)	3,000

During the past several years, significant effort has been expended by representatives of both the public and private space sectors in examining alternatives for civil space exploration goals and strategies, and in examining the role of exploration in the overall context of the nation's future space program. From such study and debate has emerged a consensus - that the expansion of human presence and activity beyond Earth orbit is both an appropriate and inevitable long-term focus for the nation's space program. The scientific, technological, and educational returns that will flow from a return to the Moon and expeditions to Mars will provide an important foundation for the nation's economic and social development in the twenty-first century.

Both the Augustine Report and the Synthesis Report provided recommendations for exploration activities focused on the Moon and Mars, The Augustine Report recommended that the "Mission from Planet Earth" be configured to an open-ended schedule, tailored to match the availability of funds. The Synthesis Group recommended four possible general strategies for Space Exploration, but the details of how to accomplish those strategies were not defined. Regardless of which strategy is pursued and what timetable is ultimately selected, there are certain types of information that will be required to support future decisions and missions. The current program plan will begin to provide that information for the Moon, which is the initial exploration focus, by making maps of the lunar terrain, resources and gravitational field. In parallel, the program is continuing to identify and assess new technologies required for humans to eventually return to the Moon and land on Mars.

Funding for conceptual mission studies for Space Exploration has been refocused toward defining requirements for early missions to begin obtaining the required data. During the balance of FY 1992, the Office of Exploration will evaluate options, select those that will best achieve the stated objectives and missions within anticipated funding constraints, and begin preparation for early unmanned precursor missions and data collection.

CHANGES FROM THE FY 1992 BUDGET ESTIMATE

In accordance with Congressional action, Space Exploration Mission Studies was reduced $10.0 million. In the past, funds in this area have been used to perform a variety of conceptual mission studies. However, with the advent of the new Office of Exploration, the goals and objectives outlined in the strategic plan have been refocused to support the small-scale precursor mission study applications which are required to fill in data gaps, support future decisions, and reduce cost and risk of subsequent robotic and manned missions.

BASIS OF FY 1993 ESTIMATE

Mission studies funding for FY 1993 is critical to the emphasis on identifying technologies that can enable or support exploration of the Moon and/or Mars. FY 1993 funds will also support the continued definition and refinement of requirements to return humans to the Moon.

BASIS OF FY 1993 FUNDING REQUIREMENT

SPACE EXPLORATION

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Exploration precursor missions	--	--	--	28,800

OBJECTIVES AND STATUS

NASA planning for space exploration recognizes the necessity to proceed in a manner that realistically reflects the constrained budget environment. For 1993, the budget is based on a strategy of supporting near-term small missions that will take advantage of the unique proximity and characteristics of the moon, and supporting research focused on key, long-lead technologies that will be necessary for any future exploration endeavors. Given this reality, the near-term exploration strategy is two-fold. First, to start small with two small-scale, robotic/automated precursor missions designed to fill gaps in our scientific and technological knowledge. Second, to undertake these missions with a management discipline that emphasizes performance within schedule and budget constraints.

The objectives of this activity are the management and execution of these two precursor missions. These missions will satisfy the following program strategies: to assemble required programmatic data; to demonstrate management ability to perform within budget and on schedule; and to minimize engineering complexity and cost. Differing management and procurement strategies will be employed to identify and benchmark the optimal approaches for acquisition of subsequent Space Exploration program elements.

Precursor mission goals identified thus far are to gather data for lunar topographical maps, lunar gravity maps, and lunar chemical and resource maps.

BASIS OF FY 1993 ESTIMATE

The FY 1993 funds will be used to initiate development of recommended candidate small-scale precursor missions that studies have indicated can provide the significant data or capabilities for potential future exploration missions. Budget estimates are based on the development of two satellites: a lunar geodetic scout that will map the lunar topography and gravity field, and a lunar resource mapper to analyze and map the chemical composition of the Moon. Instruments for these two mission will be selected from the following candidate list:

a laser altimeter and subsatellite; an x-ray florescence imager; an ion mass spectrometer; a gamma ray spectrometer; a neutron spectrometer; an alpha particle spectrometer; a magnetometer; an electron reflectometer; and a doppler gravity measurement instrument. Estimates are also based on using a variety of innovative acquisition and management techniques. Methods under consideration include: in-house development (e.g. Federal Laboratories); commercial space capabilities (data as an end-item deliverable); traditional government/prime contractor procurement, but avoiding micro-management and contract changes; and compressed development schedule ("skunkworks" approach). Preliminary planning is based on launch of the lunar resources mapper on a Delta-class vehicle in March 1995, followed by launch of the lunar geodetic scout in March 1996.

SAFETY, RELIABILITY AND
QUALITY ASSURANCE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SAFETY AND MISSION QUALITY

SAFETY, RELIABILITY AND QUALITY ASSURANCE

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
	(Thousands of Dollars)				
Safety, reliability, maintainability and quality assurance	33.000	33.600	33.600	32.500	RD 16-2
Total	33.000	33.600	33.600	32.500	

Distribution of Program Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	2,707	2,300	2,780	2,260
Kennedy Space Center	2,011	1,700	1,785	1,925
Marshall Space Flight Center	2,509	2,100	2,780	1,895
Stennis Space Center	310	550	605	860
Goddard Space Flight Center	2,518	2,900	3,695	3,270
Jet Propulsion Laboratory	6,791	3,900	4,820	4,389
Ames Research Center	480	350	125	271
Langley Research Center	1,910	2,800	1,890	1,665
Lewis Research Center	2,765	3,800	4,275	3,480
Headquarters	10.999	13.200	10.845	12.485
Total	33.000	33.600	33.600	32.500

OFFICE OF SAFETY AND MISSION QUALITY SAFETY, RELIABILITY, AND QUALITY ASSURANCE

OBJECTIVES AND JUSTIFICATION

The Office of Safety and Mission Quality (OSMQ) continues to actively support NASA-wide goals. The overall objective is to assure the safety and quality of NASA missions. This is achieved through the development, implementation, and oversight of uniform safety, reliability, maintainability, and quality assurance (SRM&QA) policies and procedures. In addition, the OSMQ conducts independent technical assessments of all major flight and nonflight projects to determine compliance to SRM&QA requirements. The SRM&QA functions include program assurance; development of technical standards and demonstration of key technologies for improving program assurance; systems assessments and trend analyses; safety (risk identification and resolution), reliability, maintainability, quality assurance; and quality management initiatives.

The major goals of the NASA's OSMQ are to:

- Maintain the SRM&QA function as an aggressive contributor to the overall NASA operation.

- Embody safety and mission assurance disciplines into the planning, development, and implementation of NASA programs and operations.

- Identify and analyze problems, implement corrective action, and ensure communication of major problems up through all levels of management.

- Provide an independent assessment of the entire NASA program implementation process including system design, development, manufacturing, procurement, test, and operations.

- Develop and ensure uniform implementation of clearly defined policies and procedures for SRM&QA throughout the Agency.

- Maintain an SRM&QA workforce of qualified people who are properly trained and equipped, dedicated to superior performance and the pursuit of excellence, and who will lead the entire NASA/industry work force in implementing continuous SRM&QA improvement.

The OSMQ aggressively provides SRM&QA leadership across all levels of NASA programs. A key function is to provide independent judgments of program decisions/issues based on SRM&QA analyses, particularly where there is no engineering consensus or a high degree of uncertainty on critical points that could affect program safety and mission success. The OSMQ ensures that SRM&QA requirements are integrated into the earliest phases of development for space and aeronautics programs. Conformance with SRM&QA policies and procedures is monitored through each program phase to assure proper attention to risk. Implementation of the SRM&QA program is assessed through SRM&QA surveys and functional management reviews of the NASA centers.

The Office's safety activities include developing top-level safety policies, defining program-specific safety requirements, and identifing risks. The OSMQ also supports NASA's risk management process by conducting hazard analyses and quantitative risk assessments to categorize and respond to safety threats.

The OSMQ provides NASA-wide/industry technical support in reliability and maintainability areas such as parts quality/product assurance, materials treatments and processes, and microcircuit radiation effects evaluations. A key activity is to identify "reliability best practices" for distribution to all NASA centers and contractors.

The OSMQ manages a certification program for mechanical parts and monitors the subtier supplier control system. Primary goals are to improve parts reliability and reduce the risk of substandard parts use. The OSMQ also manages a program to control the reliability, quality, and use of electrical, electronic, and electromechanical (EEE) parts in spacecraft. Goals include, for example, radiation testing of EEE parts and development of a NASA-approved standard parts list (MIL-STD-975).

In recognition of the Agency's increasingly complex software requirements, OSMQ has a comprehensive software assurance program that addresses mission-essential software systems. This program assures that methods, processes, and tools to evaluate software quality are maintained current with the demands of advanced systems. The OSMQ also evaluates and improves NASA's software engineering/management processes and products through development of technical standards, measurements, and technology transfer. The OSMQ strives to fully integrate software engineering and assurance into the systems development and operations process. The OSMQ performs trend analyses using mission performance and problem data to identify/predict areas that warrant preventive measures, recurrence controls, or corrective actions.

The Programs Assurance organization is the primary interface between OSMQ and NASA Headquarters program offices. Key functions are to establish program-level SRM&QA requirements to address the unique mission, design, and operational characteristics of each program; and to ensure compliance with Agency and program SRM&QA policies. The Programs Assurance organization maintains rigorous oversight of large-scale, complex operations such as the Space Shuttle program and the Space Station Freedom (SSF) program.

Independent safety and reliability assessments of the SSF program include overall risk identification and analyses. Safety and product assurance reviews address program issues such as system design/configuration, structural vibration, fabrication timeliness, on-orbit maintenance and repair, on-orbit fire safety, thermal control, and plasma/Station electrical interactions.

In the Technical Standards area, the OSMQ develops engineering standards and practices to provide a basis for improvements of program/mission assurance. In this regard, the OSMQ is planning and managing NASA's transition to the metric system of measurement.

A major objective is to support development and demonstration of applied technologies to improve system reliability and mission performance. Key areas of emphasis include aerospace batteries, electronic packaging, pyrotechnic devices, and advanced guidance systems. Results from these program activities support the development of future space projects, and will lead to improvements in overall mission capability.

Testing policies and procedures are a key focus. The OSMQ provides uniform test policy and assesses test standards to assure consistent acceptance and qualification testing for space hardware. A primary objective is to establish and implement SRM&QA requirements for testing, qualifying, and accepting space systems technology.

The OSMQ supports the promulgation of the Agency's Total Quality Management (TQM) philosophy and initiatives throughout NASA, its contractors, and suppliers.

The OSMQ maintains a NASA data base of "lessons learned" from past programs that is applicable to all SRM&QA/engineering disciplines for both ongoing and future programs.

BASIS OF FY 1993 ESTIMATE

The continuing goal of the OSMQ in FY 1993 is to provide innovative leadership in assuring safety and mission quality. In FY 1993, OSMQ will expand and strengthen the key roles of program/project oversight, and development of program-level SRM&QA policy as well as project-specific plans and procedures. The funding will strengthen OSMQ's capability to ensure compliance with NASA SRM&QA directives, and to perform independent and "second-look" evaluations of critical program issues. Another major objective is to improve problem reporting capabilities that are essential for prompt identification of mission-critical problems or risks to ensure their timely and cost-effective resolutions. Major program initiatives planned for FY 1993 are described below.

The Technical Standards program will further consolidate NASA technical guidance into a set of NASA-wide engineering standards, and accelerate preparation for transition to the metric system through adaptation of documents and qualification of metric standard parts to support hardware development. Continued development of safe, reliable pyrotechnic actuated systems will result in flight demonstration of a laser-initiated safe/arm device. Qualification of an advanced prototype solid-state gyroscope is also planned. New initiatives in electronic packaging and power systems will focus on preparation of a surface mount technology design handbook and qualification of multi-chip modules, advanced wiring systems, and nickel-metal hydride and nickel-hydrogen cells for aerospace batteries.

The safety program will implement a safety strategic plan ("Safety 2000"); independent mission safety evaluations will be conducted for each NASA mission; an integrated safety process for nuclear propulsion technologies will be developed; and standardized safety training will be implemented throughout NASA. In FY 1993, the Safety organization also will develop policy and procedures for space debris risk management.

Reliability and maintainability initiatives planned for FY 1993 include improving the safety, performance, and reliability of wiring systems for space applications. Uniform standards, guidelines, and procedures will be developed to support design, test, and qualification of NASA flight hardware/systems. Similarly, OSMQ will develop policies, standards, methods, and tools to ensure production of reliable and maintainable complex software systems.

The OSMQ will enhance the NASA program management and design review process by improving systems engineering methods and procedures. The interagency development of product data exchange standards will expand, and OSMQ will support application of these standards to NASA programs.

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ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Educational affairs..................	25,800	27,600	29,800	33,700	RD 17-2
Minority university research..........	17,200	22,000	22,000	22,700	RD 17-9
Space grant college and fellowship....	12.100	15.000	15.000	15.000	RD 17-16
Total............................	55.100	64,600	66.800	71.400	

RESEARCH AND DEVELOPMENT

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ACADEMIC PROGRAMS

EDUCATIONAL AFFAIRS

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Graduate student researchers	6.900	7.000	7.000	8.200	RD 17-4
Summer faculty fellowships	3.800	4.000	4.000	4.000	RD 17-4
Innovative research	2.700	2.900	2.900	3.100	RD 17-5
Space applications	2.800	2.800	2.800	2.800	RD 17-6
Aerospace education services (AESP)	6.000	6.100	6.100	7.000	RD 17-7
Innovative education	3.600	4.800	5.500	7.600	RD 17-7
Educational technology	--	--	1.500	1.000	RD 17-8
Total	25.800	27.600	29.800	33.700	

Distribution of Program Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Ames Research Center	938	1.183	1.280	1.310
Goddard Space Flight Center	961	1.112	1,210	1.240
Jet Propulsion Laboratory	896	1.073	1.146	1.176
Johnson Space Center	1.005	1.217	1.247	1.277
Kennedy Space Center	590	826	1.126	1.156
Langley Research Center	995	1.260	1.334	1.390
Lewis Research Center	1.100	1.213	1.350	1.445
Marshall Space Flight Center	1.097	1.225	1.387	1.480
Stennis Space Center	695	746	920	1.150
Headquarters	17.523	17.745	18.800	22.076
Total	25.800	27.600	29.800	33.700

ACADEMIC PROGRAMS **EDUCATIONAL AFFAIRS**

OBJECTIVES AND JUSTIFICATION

One of the National Goals for Education is that by the year 2000, U.S. students will be first in the world in science and mathematics achievement. NASA's academic program directly supports that goal and others through programs designed to capture and channel student interest in science, engineering, mathematics and technology, as well as enhance teacher and faculty knowledge and skills related to these subjects. These agencywide pre-college, university and minority university programs are in support of NASA's Education mission to produce more U.S. scientists, engineers, and technicians for its future workforce needs.

The specific objectives of the Educational Affairs program are:

- To involve the pre-college educational community, students, teachers, and administrators in better understanding the knowledge derived from NASA research and development and its application to the study of mathematics, science and technology;

- To encourage elementary level students to take greater interest in mathematics, science, and technology through the use of advanced instructional technology, development of strong teacher resource centers, curriculum materials designed for the elementary level, and the initiation of cooperative relationships with private industry, local school systems, and community organizations;

- To significantly increase the number of highly trained scientists and engineers in aeronautics, space science, space applications and space technology to meet the continuing needs of the national aerospace effort;

- To facilitate the direct interaction, further the professional knowledge and stimulate the exchange of ideas between university faculty members and NASA scientists and engineers;

- To support innovative research at U.S. institutions of higher learning that is in the formative or embryonic stage and that would appear to have significant potential to advance space science and applications programs; and,

- To provide for the development and use of a core, long-term U.S. national university capability to conduct multiyear, Earth science discipline-oriented applied research and remote sensing.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The total increase of **$2.2** million in **FY 1992** is additional funding appropriated by Congress to establish NASA's Educational Technology initiative (Classroom of the Future) and to expand Innovative Education programs to fund community colleges to ensure the continuation of qualified technicians for the aerospace effort, and for development of curriculum materials which relate to NASA missions that can be used in the classroom.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Graduate student researchers	6,900	7,000	7,000	8,200

OBJECTIVES AND STATUS

The Graduate Student Researchers program, initiated in **1980**, provides graduate fellowships nationwide to post-baccalaureate U.S. citizens to conduct thesis research at a NASA Center or to carry out a program of study or research at their home institution. Awards are made to graduate students for a maximum of three years. On an annual basis, NASA supports approximately **300** graduate students pursuing the masters or doctorate degrees, awarding **80** new awards each year. This program channels graduate students towards careers in science, engineering, mathematics and technology.

BASIS OF FY 1993 ESTIMATE

The FY **1993** request will support continuation of the current program and the establishment of an undergraduate fellowship program and additional fellowships at the graduate level, increasing the number of annual awards available yearly at each NASA center.

Summer faculty fellowships	3,800	4,000	4,000	4,000

OBJECTIVES AND STATUS

The NASA Summer Faculty Fellowship program has completed **28** years of operation. This program provides highly beneficial opportunities for engineering and science faculty throughout the United States by allowing participation in NASA research. This program has contributed significantly to the improvement of both undergraduate and graduate education, and directly benefitted NASA, universities, faculty, students, and the Nation.

The Summer Faculty Fellowship program enables university faculty to spend ten weeks working directly with scientists and engineers at NASA Centers on problems of mutual interest. Participants must have a minimum of two years teaching experience and must be citizens of the United States. The program is designed to further the professional knowledge of faculty members, to stimulate an exchange of ideas between participants and NASA, and to enrich the research and teaching activities of the participants' home institutions. This activity is operated cooperatively with the American Society for Engineering Education (ASEE).

Approximately **300** university faculty are supported annually for ten weeks. Evaluations conducted by ASEE of the program indicate that approximately **30-40** percent of the participating faculty subsequently receive NASA research grants or contracts.

BASIS OF FY 1993 ESTIMATE

The **FY 1993** funding level supports program continuation at current activity levels.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Innovative research	**2,700**	**2,900**	**2,900**	**3,100**

OBJECTIVES AND STATUS

Over the past decade, it has become increasingly apparent that a key to the future health and well-being of the space science and applications program lies in having the capacity to explore new ideas or novel technical approaches to research. In response to this need, the Innovative Research program was established within the Office of Space Science and Applications to support research which, while still in its formative stage, has already demonstrated potential for significant advances for Space Science and Applications programs. The program is intended to provide a mechanism for the funding of scientifically sound proposals which might not be funded through normal channels either because of their interdisciplinary nature or because they are in some sense, speculative or risky. The long-term goal is to help the new ideas mature to a state of acceptability within particular science discipline resources.

The Innovative Research program was initiated in **1980**. Announcements of the availability of funds and NASA's interest in receiving proposals for this type of research have been issued in **1980**, **1982**, **1985**, **1988**, and **1991**. Emphasis in the program is on the support of innovative research at universities and colleges. The program also emphasizes support to new researchers who have only recently completed graduate training. The primary criterion for inclusion in the program has been originality and the promise for innovation of the work being proposed. Over the past several years, a number of major technical advances have resulted from research supported by this program, such as the development of new infrared detector technology using nonstandard scientific approaches.

BASIS OF FY 1993 ESTIMATE

The FY 1993 funding will provide for continuation of support for 24 new projects selected in 1991 and allow a few additional awards to be initiated.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Space applications	2,800	2,800	2,800	2,800

OBJECTIVES AND STATUS

The objectives of the Space Applications program are: to develop and use core U.S. university capabilities to conduct basic and applied space science research; to establish and maintain multidisciplinary remote sensing techniques for Earth sciences; and, to promote science and engineering education through NASA and university partnerships. Through the Space Applications program, a geographically distributed network of universities has been established which is responsible for conducting research and development in remote sensing data applications, the study of Earth science processes, and Earth resources management. This network supports NASA's Joint Venture in Space Research (JOVE), whose objectives are to increase the participation of U.S. academic institutions in NASA research and to enhance American education in science, math and technical fields.

BASIS OF FY 1993 ESTIMATE

Through this program, a knowledgeable research community for remote sensing has been established, and the evolving field of spaceborne remote sensing continues to mature. In FY 1993, the Space Applications program will continue to focus on working with the university community to prepare for the availability of space-based remote sensing from the U.S. Global Change program. The university community's strong participation in Global Change research is crucial for assuring continued U.S. leadership in Space Applications. Through the JOVE component of Space Applications, NASA will provide research data to a broader range of academic institutions in exchange for faculty and student research time. Faculty at institutions with limited prior involvement in NASA research are encouraged to become members of research teams at NASA field centers and established mentor institutions. The JOVE program also promotes educational outreach and provides for the dissemination of space science information at various curriculum levels.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Aerospace education services (AESP) ...	6,000	6,100	**6,100**	**7,000**

OBJECTIVES AND STATUS

The Aerospace Education Services Program (AESP), also known as Spacemobile, is NASA's premier outreach program. The AESP specialists, all former teachers themselves, stimulate millions of students and teachers each year by using aeronautics and space as a catalyst in the teaching of science, mathematics and technology. From September to June each year AESP specialists visit schools throughout the United States, conducting student assemblies and teacher workshops. During the summer, AESP specialists conduct teacher workshops at the NASA Centers and various colleges and universities.

BASIS **OF FY** 1993 ESTIMATE

The FY **1993** funding will allow for continuation of the current program with increased funding targeted toward increasing the number of specialists and upgrading aerospace models and vans.

Innovative education	3,600	4,800	***5,500***	**7,600**

OBJECTIVES AND STATUS

The Innovative Education program includes a series of programs targeted at both pre-college teachers and students. The goal is to enhance and improve the teaching of science, mathematics and technology at the elementary and secondary level by using aeronautics and space as a theme and motivational factor. Programs included are: NASA Education Workshops for Math and Science Teachers (NEWMAST), NASA Education Workshops for Elementary School Teachers (NEWEST), the Space Science Student Involvement Program (SSIP), Teacher Resource Centers, Summer High School Apprentice Program (SHARP), and community colleges.

CHANGES FROM **FY** 1992 BUDGET ESTIMATE

The **FY 1992** funding will allow for continuation of the current program with increases in the level of activity targeted toward underrepresented minority students through the SHARP activity, and the expansion of the Regional Teacher Resource Centers across the nation. The increased funding will be used to establish a pilot program with community colleges to ensure the continuation of quality technicians for the aerospace effort and for development of curriculum materials which relate to NASA missions that can be used in the classroom.

BASIS FOR FY 1993 ESTIMATE

The FY 1993 funding provides for expansion of elementary and secondary workshops, from approximately 250 to 1,000, establishment of an education curriculum development capability, expansion of our teacher resource center network to all 50 states, continuation of the Space Science Student Involvement Program and the Summer High School Apprentice Program, and continuation of the community college program.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Educational technology	--	--	1,500	1,000

OBJECTIVES AND STATUS

NASA's Education Technology effort is an essential component of the agency's Education program. Educational technology products and services produced will ensure that NASA is able to develop the same level of leadership in high technology education as it has in aeronautics and space technology. Additionally, the 21st Century Classroom, a component of the Classroom of the Future, will serve as a research and evaluation center where students and their teachers can utilize advanced educational technologies.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The FY 1992 funding carries out the direction of Congress to establish NASA's educational technology initiative to support the NASA Classroom of the Future and the development of videodiscs, computer software, and telecommunications network.

BASIS FOR FY 1993 ESTIMATE

The FY 1993 funding will allow for the development of several technology-based products of high priority to the Education Division. These include videodisc for environmental science, a telecourse for teachers, and enhancements to the Spacelink Computer Information system.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

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ACADEMIC PROGRAMS — MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Historically black colleges and universities	9,100	11,000	11,000	11,400	RD 17-12
Other minority universities	4,400	4,700	4,700	4,800	RD 17-13
Graduate student researchers program (underrepresented minority focus) ...	2,200	3,300	3,300	3,400	RD 17-14
Undergraduate student researchers program (underrepresented minority focus)	1,500	3,000	3,000	3,100	RD 17-15
TOTAL	17,200	22,000	22,000	22,700	

Distribution of Program Amount by Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	491	872	791	941
Kennedy Space Center	200	612	100	260
Goddard Space Flight Center	1,114	905	800	850
Jet Propulsion Laboratory	100	500	600	700
Ames Research Center..................	617	789	412	512
Stennis Space Center	190	324	290	340
Langley Research Center	325	1,840	2,486	1,186
Marshall Space Flight Center	316	1,230	1,704	814
Headquarters	13,600	14,480	14,220	16,381
Lewis Research Center	247	448	597	716
TOTAL	17,200	22,000	22,000	22,700

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS — MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

OBJECTIVES AND JUSTIFICATION

The goal of the NASA Minority University Research and Education Program is to improve and expand the research capability of selected Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs), and to encourage the development of a resource pool of talent through a strong research focus and alliances between HBCUs, OMUs, majority research universities, industry, and other Federal R&D agencies. One of the objectives of the President's goal in math and science education is to increase the number of women and minority graduate and undergraduate students receiving degrees in math, science and engineering. NASA endeavors to achieve this goal through the aggressive implementation of initiatives for HBCUs; by developing closer relationships with OMUs; and by continuing the Graduate Student Researchers Program, Underrepresented Minority Focus (GSRP/UMF); and, established in FY 1991, the Undergraduate Student Researchers Programs Underrepresented Minority Focus (USRP/UMF).

NASA's HBCU initiative is mandated by Executive Order 12677, which requires Federal agencies to increase significantly the involvement of HBCUs in Federally sponsored programs. Congress also mandated NASA, in FY 1985, to build closer relationships with other universities that educate large numbers of minority students who are underrepresented in science and engineering. Additionally, NASA is being responsive to the Executive Order on Educational Excellence for Hispanic Americans, signed on September 24, 1990, which directs Federal agencies to be actively involved in helping advance educational opportunities for Hispanic Americans. NASA has implemented those initiatives through research and training grants sponsored through the Minority University Program in the Office of Equal Opportunity Programs (OEOP). In FY 1992, the NASA Institutional Program Offices (IPOs) will become more directly involved and responsible for the selection, funding and conduct of minority university research. The program offices are working collaboratively with the OEOP to insure these minority institutions and principal investigators will ultimately compete successfully in NASA's mainstream research processes. This new process will also facilitate NASA's efforts to comply with the Congressional mandate that 8 percent of NASA's total procurements shall go to small and minority businesses including HBCUs and minority universities.

To encourage the development of talent at the undergraduate and graduate level, NASA will continue the GSRP/UMF and the USRP/UMF. The USRP/UMF was introduced in FY 1991, based on the recommendations of NASA principal investigators. The concept also is in consonant with the recommendations of the National Task Force on Women, Minorities, and the Handicapped in Science and Technology, which urged the establishment of a variety of scholarships, fellowships, hands-on research experience and other support to capture and develop these groups.

It has become increasingly apparent that many promising minority high school graduates with excellent grade point averages and SAT scores enter college, but do not elect science and engineering fields. Further, many of the minority science and engineering students who succeed at the undergraduate level and who have the ability to do graduate level research never consider research as a career option. Through the GSRP/UMF, NASA principal investigators involve minority students pursuing masters and Ph.D. degrees in areas of interest to NASA in NASA-sponsored research projects. The objective of both these programs is to build a pipeline of talented underrepresented minority students to ensure increased numbers for graduate studies. Scientific and Technology Education Development Grants (Training Grants) will be expanded to provide developmental research experiences for students and faculty members. These grants will be focused toward specific research disciplines relevant to NASA requirements in science and technology. Ultimately, it is anticipated that the institutions involved with these grants will develop an improved research capability in the discipline that will provide long term research opportunities for faculty principal investigators and student researchers. Building research infrastructure is key to the development of NASA quality research capability.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Historically black colleges and universities	9,100	11,000	11,000	11,400

OBJECTIVES AND STATUS

The objectives of the HBCU Program are to continue to increase the level of participation with HBCUs and to strengthen the infrastructure of selected universities. Special emphasis will be placed on enhancing the math and science abilities of students and principal investigators, which will lead to careers in science and engineering research. Demographic changes forecast for the United States make it mandatory for NASA to increase the science and engineering pipeline of students available in order to sustain workforce technical requirements through the 21st century.

During FY 1992, seven HBCU Research Centers were competitively selected in science and technology disciplines related to NASA research requirements. These HBCU Research Centers will receive initial funding in FY 1992 and will begin regular meetings with the NASA Field Installations and Headquarters program offices in order to develop focused research activities leading to "mainstream" capability at the HBCUs to include principal investigators, undergraduate students and graduate students. Collaborative efforts between the Minority University Research and Education Programs Division and the NASA technical offices will provide long term guidance for the HBCU Research Centers with funding and technical oversight.

Funding for individual Principal Investigator unsolicited proposals will continue and grants will be awarded for research and for training to bring new talented faculty members into the research arena on a regular basis. The new Scientific and Technology Education Development Grants, to begin in FY 1992, will provide seed funding for a broader range of space science and technology efforts at HBCUs, with emphasis on nurturing new technologies for the Office of Space Science and Applications (OSSA), the Office of Aeronautics and Space Technology (OAST) and other NASA technical offices.

All ongoing and new HBCU research and training activities will be jointly funded by OEOP, OSSA, OAST and other applicable offices. This collaborative effort will accelerate the developmental process at the HBCU institutions.

BASIS OF FY 1993 ESTIMATE

Funding for FY 1993 will sustain the seven HBCU Research Centers, provide support for individual Principal Investigator Grants, continue a focused award of training grants and, jointly with the NASA technical offices, evaluate progress toward goals and milestones.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Other minority universities	4,400	4,700	4,700	4,800

OBJECTIVES AND STATUS

The objectives of the OMU Program are to expand and develop a comprehensive program of research and education with institutions and faculty serving underrepresented minority students in science and engineering. Working in collaboration with NASA Field Centers and Headquarters Program Offices, the Minority University Research and Education Programs (MUREP) Division will establish scholarships, research grants, and training grants to increase the pool of underrepresented minority graduate and undergraduate students pursuing degrees in science, engineering and related disciplines.

In 1991 a meeting was held with an ad hoc OMU Advisory group which led to a greater understanding of their needs and requirements to develop the research capability of the faculty and the institutions. A new research program entitled the Faculty Researchers Initiation Award, Underrepresented Minority Focus (FRIA/UMF) Program will be implemented during FY 1992. This program is designed to identify talented underrepresented minority faculty at OMUs who have previously been unable to receive NASA research awards, but who are interested and capable of contributing to NASA aerospace research efforts. The new awards will support the faculty member and several students for a period of five years to develop the capability to compete in mainstream NASA research efforts.

BASIS OF FY 1993 ESTIMATE

To strengthen and expand the agency's relationships with OMUs, NASA will continue its strategies of site visits to OMUs; hold an annual meeting of the ad hoc Advisory Group on OMUs; and broaden the initial list of OMUs with programs in NASA-related fields of interest. Additionally, MUREP will continue to work closely with the Headquarters Program Offices and NASA Field Centers to issue a second call for proposals program notice for the FRIA/UMF Program. It is anticipated that each NASA installation will be able to identify competitively at least three new proposals for funding that benefit their center's mission. The FY 1993 budget estimate is based on making at least 25 new awards. Funding is also included in FY 1993 to support an evaluation component in every OMU educational grant awarded.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Graduate student researchers program (underrepresented minority focus) ..	2,200	3,300	3,300	3,400

OBJECTIVES AND STATUS

The objectives of this program are to enhance the development of underrepresented minority talent in an effective way so as to utilize the potential of this nation's diverse citizenry; and to increase the size of the resource pool of research skills that will be needed to meet aerospace and other technological objectives of the future. Principal investigators who have NASA research grants and a need for further student involvement will be encouraged to seek out talented underrepresented minority students and involve them in their NASA research projects. The underrepresented minorities who are the special focus of this program include Blacks, Hispanics, American Indians and Pacific Islanders. They must be enrolled in masters or doctoral programs in engineering, physics, mathematics, computer science, biology, or other disciplines of interest to NASA. Data show that almost 60 percent of the GSRP/UMF students are in Ph.D. programs, and that Blacks and Hispanics make up about 90 percent of the program population. This is particularly encouraging since recent national scientific manpower data show Blacks and Hispanics making the least educational advancement of all target groups in science and engineering.

Each student generally participates in this program for three years. In FY 1991, a total of 102 students were participating, of which 35 were new students. This total included 30 Black males, 12 Black females, 1 American Indian female, 3 Pacific Islander males, and 3 Pacific Islander females. In FY 1992, the total planned number of students is 107, of which 50 will be new students reflecting the upward trend in applications.

BASIS OF FY 1993 ESTIMATE

Funding in FY 1993 will support a total of 138 graduate students, of which 55 will be new to the program. Funding is also required to continue support to students who are in the second and third years of participation. This increased participation demonstrates the large growth in interest and competitiveness within the program.

	1991 Actual	1992 Budget Estimate	1992 Budget Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Undergraduate student researchers program (underrepresented minority focus) ..	1,500	3,000	3,000	3,100

OBJECTIVES AND STATUS

This new program, started in FY 1991, identified 80 high ability freshman level underrepresented minority students majoring in science and/or engineering and awarded them portable scholarships to selected universities with proven records of recruiting, retaining and graduating minority science and engineering students. With a projected success rate of at least 62 percent, this effort will grow to a level where at the fourth year, NASA expects to have about 200 students in the program. The pipeline of undergraduate minority students majoring in the physical and life sciences and engineering coming from this program is expected to impact substantially and positively NASA's freshout hiring needs. Even more important, these students are being targeted for advanced studies and research careers that will ultimately get them to the terminal degree levels. The USRP/UMF may serve as a feeder to the GSRP/UMF. Identified students receive tuition support; are monitored, tutored and nurtured; and will by their junior year be a part of NASA's Co-op program or become research assistants working with principal investigators at their universities on NASA sponsored research, or working at a NASA Installation. The primary objective is to encourage talented underrepresented minorities to choose, as a career option, graduate level studies in science and engineering. FY 1992 saw a major growth in the program as it expanded to 200 students representing scientific and technical disciplines related to NASA's work force needs projected over the next ten years.

BASIS OF FY 1993 ESTIMATE

The funding level of the USRP/UMF will approximate the funding level of the GSRP/UMF. Since the undergraduate component will serve as a feeder to the graduate component, the proposed budget structure for the undergraduate component represents a natural progression. NASA's goal is to have a continuous flow of minority undergraduate and graduate level students in science and engineering educational tracks.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 **ESTIMATES**

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ACADEMIC PROGRAMS | **NATIONAL SPACE GRANT COLLEGE AND FELLOWSHIPS**

OF **RES** I E

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space grant college and fellowships...	12,100	15,000	15,000	15,000	RD 17-16
Distribution of Proeram Amount by Installation					
Headquarters	12,100	15.000	15.000	15.000	
Total	12.100	15.000	15.000	15.000	

OBJECTIVES AND **STATUS**

The Space Grant College and Fellowships program is composed of three principal and interrelated elements: Designated Space Grant Colleges/Consortia, Space Grant Program Consortia, and Space Grant Capability Enhancement Consortia. Designated Space Grant Colleges/Consortia, of which 21 were selected in 1989, are preeminent institutions which are substantially involved in a broad spectrum of NASA research, offer advanced study in aerospace fields, and are significantly involved in related public service. Designated Colleges/Consortia each received $75,000 in start-up funds in FY 1989 and from $250,000-$325,000 in FY 1990 and 1991, depending on consortium affiliations. In FY 1992, designated schools will receive from $295,000-$380,000, which includes a $20,000 augmentation to all schools, and a chance to receive additional funding of $35,000 depending upon the size of the consortium. In FY 1991, a new competition took place; consortia within states not represented by Designated Colleges/Consortia were invited to apply either for Program Grants or for Capability Enhancement Grants (the difference between the two types of programs is related to current involvement in aerospace fields.) Of the twenty-nine proposals received, 14 were funded as Program Grants, 12 as Capability Enhancement Grants and three as planning grants. Selections were announced in February 1991. Program Grant and Capability Grant awardees received $150,000 in FY 1991, a portion of which was to be used for fellowships. In FY 1992, the states received an additional augmentation of $20,000, with a chance to receive an additional $35,000, depending upon the size of the consortium. It is anticipated that the three states which received planning grants $25,000 each, will be brought into the program as fully-funded proposals, along with Vermont and Puerto Rico, in FY 1992.

BASIS OF FY 1993 ESTIMATE

The FY 1993 funding will continue implementation of the National Space Grant College and Fellowships program by funding the original 21 consortia and fully funding 31 Phase II grantees. Funds will also be used to perform critical program evaluation which includes site visits to Space Grant College campuses and to convene the legislatively-mandated Space Grant Review Panel.

TRACKING AND DATA
ADVANCED SYSTEMS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS

TRACKING AND DATA ADVANCED SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Advanced systems	20,000	22,000	22,000	23,200	RD 18-2
Distribution of Program Amount bv Installation					
Goddard Space Flight Center	5,600	6,100	6,200	6,200	
Headquarters	410	400	400	500	
Jet Propulsion Laboratory	13.990	15.500	15.400	16.500	
Total	20.000	22.000	22.000	23.200	

BASIS OF FY 1993 FUNDING REQUIREMENT

ADVANCED SYSTEMS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Advanced systems	20,000	22,000	22,000	23,200

OBJECTIVES AND STATUS

The objective of the Advanced Systems program is to improve the performance, capability, and reliability of future space missions in the critical areas of communications, navigation, and mission operations. The program achieves this by evaluating and developing new technologies to demonstrate their feasibility to a level such that field implementation can be undertaken with confidence. Over the years, the Research and Development (R&D) under this program has enabled the cost-effective introduction of new techniques and new technologies into the Deep Space Network, the Space Network, and Communications and Data Systems. Maintaining the program is critical for our continued ability in the future.

BASIS FOR FY 1993 ESTIMATE

The activities in FY 1993 will include position determination of Earth-orbiting spacecraft to an accuracy of a few centimeters, and determination from the Earth of the angular direction of planetary mission spacecraft to within five nano-radians. These advances in tracking and navigation are essential for highly accurate science and communication technologies for space missions such as Galileo, Mars Observer, and Tracking and Data Relay Satellite 11.

For ground-to-space communications, development work will be done in utilization of both radio and optical frequencies. Radio frequency technology developments will include transmitters, receivers, multi-frequency feeds, and reflectors at S-, X-, Ku-bands (2, 8, 12, and 32 GHz). Optical communications systems will be studied and concepts and developments will be analyzed and compared with microwave systems from the viewpoint of cost and performance.

Several future missions will have high-resolution sensors and payloads operating with high data rates and large data volu technology development to process, store and transmit data at high rates and large volumes for such missions. Another pa improving the efficiency and capabilities of mission operations. This includes: (1) development and application of advan -- expert systems, artificial intelligence, etc. -- to mission operations; (2) increased automation and improved graphics effective human-machine interaction; and (3) advances in the area of telescience, which would enable real-time interactio Earth and their spaceborne instruments.

SPACE FLIGHT
CONTROL AND DATA
COMMUNICATIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1993 ESTIMATES

GENERAL STATEMENT

The objective of the National Aeronautics and Space Administration program of Space Flight, Control and Data Communications is to provide for the operational activities of the space transportation system and the tracking and communication system support to all NASA flight projects. This objective is achieved through the following elements:

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY: A program to provide a fully capable fleet of Space Shuttle orbiters, main engines, launch site and mission operations control requirements, spares inventory, production tooling, and other investments needed to maintain the long term viability of the Shuttle program.

SHUTTLE OPERATIONS: A program to provide the standard operational support services for the Space Shuttle. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and manpower, propellants, and other materials are furnished to conduct both flight and ground (launch and landing) operations.

EXPENDABLE LAUNCH VEHICLES: A program to provide for procurement of expendable launch vehicle services.

SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS: A program to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects using ground-based and satellite (Tracking and Data Relay Satellite System) components.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1993 ESTIMATES

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Millions of Dollars)			
SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	1314.0	1288.9	1327.8	1012.8
SHUTTLE OPERATIONS	2752.4	3023.6	2943.4	3115.2
EXPENDABLE LAUNCH VEHICLES	229.2	341.9	195.3	217.5
SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS	828.8	953.9	918.3	921.0
TOTAL	5124.4	5608.3	5384.4	5266.5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

For necessary expenses, not otherwise provided for, in support of space flight, spacecraft control and communications activities of the National Aeronautics and Space Administration, including operations, production, services, minor construction, maintenance, repair, rehabilitation, and modification of real and personal property; tracking and data relay satellite services as authorized by law; purchase, [hire] *lease, charter,* maintenance and operation of [other than] *mission and* administrative aircraft; [$5,157,075,000] *$5,266,500,000,* to remain available until September 30, [1993, of which $32,674,796 shall be used only for the purpose of payment, to the Federal Financing Bank, for the Tracking and Data Relay Satellite System (TDRSS) loan: *Provided,* That such payment shall constitute settlement of all amounts owed on said loan] *1994. (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1992; additional authorizing legislation to be proposed.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

REIMBURSABLE SUMMARY
(In thousands of dollars)

		Budeet Plan	
	FY 1991	FY 1992	FY 1993
Shuttle production and operational capability	31,837	69,810	15,632
Shuttle operations	32,751	113,300	45,000
Expendable launch vehicles	71,512	75,045	56,587
Space and ground networks, communications and data systems	41.237	85.800	90.000
Total	177.337	343.955	207.219

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1993 ESTIMATES

DISTRUBTION OF SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Transportation Sys	1991	4,295,545	1,185,700	923,700	1,881,500	24,600	105,100	2,600	5,600	200	121,700	44,845
	1992	4,466,500	1,197,000	1,031,200	1,885,500	41,000	106,000	0	5,900	0	61,000	138,900
	1993	4,345,500	1,324,700	1,064,000	1,628,400	30,600	78,800	0	5,800	0	62,600	150,600
Shuttle Production	1991	1,313,945	404,300	137,800	724,700	22,100	---	2,600	---	200	4,500	17,745
	1992	1,327,800	380,700	118,600	755,200	28,600	---	---	---	---	---	44,700
	1993	1,012,800	420,200	110,000	422,100	18,000	---	---	---	---	---	42,500
Shuttle Operations	1991	2,752,400	781,400	780,500	1,156,800	2,500	---	---	5,600	---	---	25,600
	1992	2,943,400	816,300	903,800	1,130,300	12,400	---	---	5,900	---	---	74,700
	1993	3,115,200	904,500	946,700	1,150,900	12,600	---	---	5,800	---	---	94,700
Expendable Launch Veh	1991	229,200	---	5,400	---	---	105,100	---	---	---	117,200	1,500
	1992	195,300	---	8,800	---	---	106,000	---	---	---	61,000	19,500
	1993	217,500	---	7,300	55,400	---	78,800	---	---	---	62,600	13,400
Tracking And Data Acqui	1991	828,789	---	---	55,775	---	569,080	147,799	13,000	130	1,060	41,945
	1992	918,275	---	700	56,300	---	595,400	177,800	13,000	---	200	74,875
	1993	921,000	---	---	64,300	---	607,800	186,100	16,100	---	200	46,500
TOTAL BUDGET PLAN	1991	5,124,334	1,185,700	923,700	1,937,275	24,600	674,180	150,399	18,600	330	122,760	86,790
	1992	5,384,775	1,197,000	1,031,900	1,941,800	41,000	701,400	177,800	18,900	0	61,200	213,775
	1993	5,266,500	1,324,700	1,064,000	1,692,700	30,600	686,600	186,100	21,900	0	62,800	197,100

SPACE TRANSPORTATION
SYSTEMS

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
	(Thousands of Dollars)				
Shuttle production and operational capability	1,313,945	1,288,900	1,327,800	1,012,800	SF 1-1
Shuttle operations	2.752.400	3.023.600	2.943.400	3.115.200	SF 2-1
Total	4.066.345	4.312.500	4.271.200	4.128.000	

Distribution of Program Amount By Installatioq

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	1,185,700	1,323,900	1,197,000	1,324,700
Kennedy Space Center	918,300	1,014,900	1,022,400	1,056,700
Marshall Space Flight Center	1,881,500	1,845,700	1,885,500	1,573,000
Stennis Space Center	24,600	33,000	41,000	30,600
Jet Propulsion Laboratory	2,600	--	--	--
Langley Research Center	200	--	--	--
Lewis Research Center	4,500	--	--	--
Ames Research Center	5,600	6,400	5,900	5,800
Headquarters	43.345	88.600	119.400	137.200
Total	4.066.345	4.312.500	4.271.200	4.128.000

OBJECTIVES AND JUSTIFICATION

The primary program objective of the Space Shuttle is to continue supporting NASA launch requirements while maintaining the program focus on safety and mission success demonstrated since returning the Shuttle to flight. The Shuttle is a key element because of its unique capabilities. The Shuttle is the first reusable space vehicle and is configured to carry many different types of space apparatus, spacecraft, scientific experiments, and national security payloads. In addition to transporting materials, equipment and spacecraft to orbit, the Shuttle offers unique capabilities such as: retrieving payloads from orbit for reuse; servicing and repairing satellites in space; transporting humans to and returning them safely from space; operating and returning space laboratories.

The Shuttle is funded under two budget line items: Shuttle Production and Operational Capability and Shuttle Operations. Shuttle Production and Operational Capability provides for continued modification and improvement to the flight elements and ground facilities. This investment is necessary to enhance Shuttle capabilities, sustain the flight rate, and expand safety and operating margins. This line item contains the following major subdivisions: Orbiter Operational Capability, Propulsion, Launch and Mission Support, and Assured Shuttle Availability (ASA). Orbiter Operational Capability includes orbiter design modifications and system improvements, a structural spares project to maintain critical manufacturing capabilities; completion of a depot capability, and continuation of work started in FY 1988 on an Extended Duration Orbiter capability (EDO). Propulsion Systems provides for continued development effort to expand safety margins in the Space Shuttle Main Engines (SSME) and Solid Rocket Boosters (SRB). Launch and Mission Support provides for support capabilities at the Johnson Space Center (JSC) and launch site equipment provisioning for the ground facilities at the Kennedy Space Center (KSC). ASA provides the necessary investments required to extend the useful life of the Shuttle system into the next century by addressing the redesign requirements for systems which face obsolescence or will become increasingly difficult to maintain.

The Shuttle Operations program provides for the launch of NASA missions, as well as missions for Department of Defense (DOD), other U.S. government agencies, and certain commercial and international users on a reimbursable basis. Within Shuttle Operations, funding is provided in four areas: flight operations, flight hardware, launch and landing operations, and research operations support. Flight operations covers the manpower required, primarily at JSC, to conduct mission operations. Flight hardware provides the necessary flight sets of external tanks, solid rocket motors, solid rocket boosters, and orbiter hardware elements (including SSME support) consistent with the Shuttle manifest. Launch and landing operations covers the manpower and recurring activities, primarily at KSC, to conduct Shuttle launches and landings. The Shuttle launch schedule calls for eight flights annually through achievement of the Space Station Manned Tended Capability (MTC) planned for FY 1996, and then nine flights annually.

PRODUCTION AND
OPERATIONAL
CAPABILITY

BASIS OF FY 1993 FUNDING REQUIREMENT

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

	1992 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
	(Thousands of Dollars)				
Orbiter operational capability	314,800	273,800	246,100	305,500	SF 1-4
Propulsion systems	761,900	622,700	715,400	357,700	SF 1-7
Launch and mission support	237,245	270,100	261,700	210,700	SF 1-10
Assured shuttle availability (ASA)	--	122.300	104.600	138.900	SF 1-12
Total	1.313.945	1.288.900	1.327.800	1.012.800	
Distribution of Program Amount by Installation					
Johnson Space Center	404,300	427,100	380,700	420,200	
Kennedy Space Center	137,800	107,500	118,600	110,000	
Marshall Space Flight Center	724,700	679,300	755,200	422,100	
Stennis Space Center	22,100	30,600	28,600	18,000	
Jet Propulsion Laboratory	2,600			--	
Langley Research Center	200			--	
Lewis Research Center	4,500	--	--	--	
Headquarters	17.745	44.400	44.700	42.500	
Total	1.313.945	1.288.900	1.327.800	1.012.800	

OBJECTIVES AND STATUS

This program provides for: orbiter design modifications and safety improvements necessary to support the Space Shuttle; continued development and testing of propulsion systems; needed capabilities at the launch site and mission control center to support the launch and flight operations process; and replacement of obsolete systems to ensure the long term viability of the Shuttle program.

Orbiter Operational Capability provides for necessary safety and performance improvements, modification kits, and mission kits that enable the orbiter fleet to satisfy flight requirements. Commensurate with the goals of the National Space Launch Strategy, the production of additional orbiters is not planned, but production of structural spares will continue. The structural spares are required to replace structural components if damaged and to maintain a limited orbiter production capability for the foreseeable future. Orbiter Operational Capability also provides for consolidation of orbiter repair capabilities into a centralized depot near the Kennedy Space Center. The Extended Duration Orbiter (EDO) development is included to increase on-orbit stay time from 7-10 days to 16 days. This will improve the Shuttle capability to support an increased variety of payload requirements. The EDO development is being supported by private industry consistent with the Administration's effort to promote more industry investment in space operations.

Propulsion systems funds the production, continued development, and extensive testing of the SSMEs and the development of capability enhancements to support SRB operational requirements. The **SSME** program is focused on improving operating margins and includes: the development and fabrication of safety, life extension, and producibility enhancements; the personnel and spare hardware used in ground testing to certify enhancements for flight and to establish life limits for new configuration hardware; and the production of replacement engines for the orbiter fleet and the test program. SSME project support activities at MSFC and other supporting activities at the Stennis Space Center (SSC) are included as well. The SRB production and capability development activities include static test firing of STS 51-L configured solid rocket motors with new development items added. These tests are used to certify the new developments for flight, to obtain engineering data on motor performance, and to reclaim reusable hardware needed for the flight program. **SRB** propulsion activities also cover modifications to booster hardware and ground support equipment as well as analysis of critical booster production processes. SRB project support activities at MSFC are included as well.

Launch and Mission Support provides for the required investment in Launch Operations and Flight Operations capability to meet Shuttle program objectives so that the planned flight rate can be achieved safely. At KSC, these investments are providing upgraded capabilities required because of obsolescence or to improve process efficiency. At JSC, mission support provides for improvements in the flight support systems. The flight support systems funded by this budget include Shuttle training and carrier aircraft, replacement and upgrade of equipment in the Mission Control Center (MCC), the Shuttle Mission Simulator (SMS), and the Flight Analysis and Design System (FADS).

Assured Shuttle Availability (ASA) provides the necessary improvements and upgrades to the flight hardware and ground systems required to maintain the long-term viability of the Shuttle program by addressing systems which are becoming obsolete and increasingly difficult to maintain. An aggressive program to replace obsolete flight hardware and ground systems is mandatory as the Shuttle ages in order to continue to realize the full investment in the program. A good example of the emerging consequences of obsolescence can be seen in the failure of the Inertial Measurement Unit (IMU) on STS-44. This flight had been planned as a 10 day mission but due to the failure of the IMU (KT-70 model) it was terminated after only 7 days. Fortunately, these older units are being replaced with an improved IMU (HAINS model) which had been initiated prior to the start of the ASA management approach. In the past, these types of activities had been funded by individual projects as requirements evolved. ASA is a strengthened management approach to ensure that the highest priority requirements are supported in a timely and cost effective manner. Individual ASA projects are funded based on a program-wide vulnerability assessment. Near term projects include: the Hardware Interface Module (HIM) card replacements at KSC; the Multifunction Electronic Display (MEDS) upgrade to the orbiter cockpits; a cable systems upgrade at KSC; and the continued development of the Alternate Turbopump.

BASIS OF FY 1993 FUNDING REQUIREMENT

ORBITER OPERATIONAL CAPABILITY

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Orbiter	186,300	143,300	162,100	196,900
Extended Duration Orbiter (EDO)	25,000	18,500	10,500	21,700
Structural spares	66,000	78,300	50,600	51,000
Systems integration	10,700	19,900	9,100	26,900
Orbiter spares........................	26.800	13.800	13.800	9.000
Total	314.800	273.800	246.100	305.500

OBJECTIVES AND STATUS

Orbiter production activities include safety modifications, capability improvements, and the development and installation of necessary hardware, software, and procedural modifications to safely fly the four orbiter fleet. Work continues on improvements to achieve greater operational capabilities, reduce operational costs, and meet system requirements. In addition, there are procurements of selected orbiter hardware improvements and associated engineering analysis tasks. Production, engineering, and logistics support of the Remote Manipulator System (RMS) is also included.

The Extended Duration Orbiter (EDO) program provides for the development of a cryogenic pallet and additional hardware to allow the extension of the on-orbit stay time from the baseline of 7-10 days to 16 days. The initial pallet development was financed by Rockwell, and funding is provided as part of the commercialization agreement. Logistics items affected by extended on-orbit operations such as repair parts for fuel cells are also included. The first flight utilizing the EDO pallet is scheduled on the initial United States Microgravity Laboratory (USML-1) mission scheduled for June 1992 on OV-102.

The structural spares program supports the goal of the National Space Launch Strategy which states: "As the nation is moving toward development of a new space launch system, the production of additional Space Shuttle orbiters is not planned. The production of spare parts should continue in the near term to support the existing Shuttle fleet and to preserve an option to acquire a replacement orbiter in the event of an orbiter loss or other demonstrable need." The structural spares program has been extended and integrated with other activities at the prime contractor so that key manufacturing skills are retained.

The revised structural spares program will bring in-house some activities which previously had been subcontracted. Work on the aft and forward fuselage, the crew module, the vertical stabilizer, and the mid body will now be performed by the prime contractor. Other components such as payload bay doors, wings, and OMS pods will continue to be subcontracted.

Systems integration tasks include the continuing development of the Program Compliance and Assurance System (PCAS) which is a comprehensive Shuttle data base that examines failure histories across all the Shuttle elements. Also included are contingency landing and abort analysis.

The completion of a full logistics capability is ongoing in orbiter spares. A logistics depot has been established near KSC for repair and maintenance of orbiter spare parts. The depot is reducing logistics program costs and shortening repair turnaround time. The depot is currently repairing, maintaining and manufacturing a large number of line replaceable units (LRU) and shop replaceable units (SRU). When the repair capability for major LRUs is completed in FY 1994, the depot will be fully operational. A concerted effort has been made to better define the manufacturing and rebuild requirements to determine the need to retain production capability at various vendors in order to complement the depot capability.

CHANGES FROM FY 1992 BUDGET ESTIMATE

FY 1992 funding for orbiter operational capability activities has decreased by $27.7 million due to a reduction in the structural spares program. Consistent with Congressional direction, the structural spares program has been rephased and extended to support a slow build of key components. Elsewhere, increases in orbiter were offset by decreases in EDO and systems integration. Orbiter increases are due to required modifications on OV-102 and cost growth on certain capability improvements. Systems integration tasks were reassessed in FY 1992 with some being deferred. Adjustments to the EDO funding requirements were made to reflect the commercial payment schedule with Rockwell on the pallet development.

E

Orbiter activities in FY 1993 include completing the implementation of the drag chute as well as continuing work on an extensive list of individual modifications, Among these efforts are: improvements to the waste collection system and the Auxiliary Power Unit controller; certification of reusable carbon-carbon; analysis of external tank separation debris; testing of the 750 PSI regulator; and other smaller modifications to the flight hardware. Support is also required during the Orbiter Maintenance Down Periods (OMDP) for OV-103 and OV-104 at KSC. These OMDPs are necessary to perform required structural inspections as well as to install key modifications on these vehicles. Various orbiter support tasks are also covered such as OMS/RCS testing at White Sands, modifications to the RMS, and support to the Crew Escape System. Beginning in FY 1993, tasks covering the Extravehicular Mobility Units (EMU) which are managed by the Orbiter project office will be funded under the orbiter budget rather than under mission support capability in Launch and Mission Support. Consolidation of all orbiter activities under the orbiter budget is the primary reason for the increase in FY 1993 from FY 1992 levels.

FY 1993 EDO funding is primarily for the financial payments of the cryogenic kit developed under a commercial agreement with Rockwell International. The kit has already been delivered and payments are scheduled on an annual basis over three years to cover the cost of the kit. Rockwell will recover the time value of their investment through potential use by non-NASA customers. Also included is funding for additional fuel cells and other logistics items required to support the added time on-orbit planned for flights utilizing the EDO capability.

In FY 1993 the structural spares program will continue the build of major structural components. Work will continue to be brought in-house on the aft and forward fuselage as well as the vertical stabilizer and the crew module. Subcontracted work on the payload bay doors, wings, and OMS pods will also be continued.

Systems integration activities will continue to support hardware changes and continued development of the Systems Integrity Assurance Program (SIAP) to monitor systems performance and trends. Analysis of abort scenarios and contingency landing studies will also be continued. In addition, starting in FY 1993, funding for the Integrated Management Information Computer (IMIC) system to support the SIAP will be included under this budget item and removed from mission support capability under the Launch and Mission Support budget. This will consolidate activities managed by the Space Shuttle Program Office and is the primary reason for the increase in FY 1993 over FY 1992 levels.

The orbiter logistics program in FY 1993 is concluding the development of the Shuttle logistics depot near KSC. This activity includes funding for maintenance manuals, training, maintenance test equipment, and special test equipment for the centralized depot and selected vendor repair sites.

PROPULSION SYSTEMS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Space shuttle main engine (SSME)	402,400	374,100	362,200	314,600
Solid rocket booster (SRB)	50,400	48,600	38,200	43,100
Advanced solid rocket motor (ASRM)	309.100	200.000	315.000	--
Total	761.900	622.700	715.400	357.700

OBJECTIVES AND STATUS

The Propulsion Systems budget provides for the production of the SSMEs and the development of the safety, reliability and producibility enhancements needed to support operational requirements for both the SSME and the SRB. Development funds for the Advanced Solid Rocket Motor (ASRM) have been deleted after FY 1992. The ASRM project represents major funding requirements, nearly half a billion dollars in FY 1993, over $400 million in FY 1994, and as much as $2.5 billion in runout to reach flight status. The near-term requirements could not be accommodated within the budget caps currently imposed on the Agency.

The SSME program funds development and certification activities to improve engine operating margins, safety, reliability, and durability, as well as to make the engine easier to produce and maintain. Development funding is provided for contractor test and engineering manpower as well as for hardware. The hardware procured includes spare parts for test engines, newly designed components like the two-duct hot gas manifold and the single coil heat exchanger, and new engines to replace those in the test fleet that reach their life limits. In addition to the development activities mentioned above, SSME propulsion funds contractor support for the Technology Test Bed program at MSFC, conducted with the Office of Aeronautics and Space Technology. The test bed provides an independent means of measuring internal engine environments and evaluating technical advances arising from the SSME development engineering efforts. SSME project support and other support, also funded in Propulsion Systems, pay for NASA supporting engineering at MSFC, support contractor work at SSC, test propellants at MSFC and SSC, and conducting special analysis and studies at LeRC.

Although the redesign of the SRB to resolve deficiencies in the previous design was completed in FY 1988, efforts to increase safety margins continue through FY 1993 and are funded in the Propulsion Systems budget. Flight data will be assessed, and recovered flight hardware will be inspected, to ensure that the boosters are performing as designed. Moreover, Technical Evaluation Motors (TEMs) produced prior to the Challenger accident will be static-fired to reclaim reusable hardware, to certify new developments for flight, and to provide data for engineering evaluation and analysis. In the absence of an ASRM, an asbestos-free program for the Redesigned Solid Rocket Motor (RSRM) will be initiated. In addition, SRB project support efforts at MSFC are funded under Propulsion Systems.

CHANGES FROM FY 1992 BUDGET ESTIMATE

FY 1992 funding requirements in Propulsion increased $92.7 million. The decrease in the main engine program is attributed to a decrease in producibility studies, product improvement activities, and project support efforts. SRB funding in FY 1992 was decreased based on a reassessment of potential changes. ASRM funding was increased $115 million based on Congressional direction. However, as a result of terminating this program, NASA and the Administration are examining termination options and assessing FY 1992 requirements.

BASIS OF FY 1993 ESTIMATE

SSME funding in the FY 1993 budget supports the continued development, testing, material procurement, fabrication, and assembly operations necessary to support the flight and ground test programs. The SSME ground test program is based on an average test rate of eight tests per month (460 seconds duration) through FY 1993. The primary purpose of this testing is to develop and flight-certify improved hardware like the Phase 11+ Powerhead (two-duct hot-gas manifold), the single-coil heat exchanger, and the Alternate Turbopumps. Ground testing will also be performed on all new or recycled flight hardware prior to acceptance. Other testing will be utilized to provide hot-fire experience and increase life limits on flight configured engines. Support for the Technology Test Bed continues as well, with nine tests, each of 150 seconds duration, scheduled in FY 1993. The current plan for the SSME test stands is that one of the three stands will be deleted in FY 1994 assuming certification testing on the Alternate Turbopumps, the Phase 11+ powerhead, and the single-coil heat exchanger are completed. The two remaining stands will be used for acceptance tests of new and recycled hardware and for tests to extend hardware life limits. New attrition engines will continue to be produced in FY 1993 to support deliveries in FY 1994 and FY 1996. Improved hardware for fleet retrofit will also continue to be produced in FY 1993. This improved hardware includes the Block II controller which is to fly for the first time in FY 1992 on Endeavor's maiden voyage. The other significant upgrades such as the Phase 11+ and the single coil heat exchanger are also being procured in FY 1993. Due to the substantial lead time on production of powerheads and heat exchangers, and the positive results from development testing thus far, the first pieces of these improved components are currently being produced. Certification is currently scheduled for mid-FY 1994.

FY 1993 funding for the SRB supports continued efforts to improve the safety and producibility of the SRB, including the Redesigned Solid Rocket Motor (RSRM). Booster funding includes: a redesign of the C-Band transponders used during booster recovery; a program to increase launch safety margins by optimizing aft skirt bias; an analysis of critical production processes in manufacturing the aft and forward assemblies of the SRB; and the design of a new test set for the integrated electronics assembly. RSRM funding completes the redesign of the ignitor joint to reduce the possibility of hot gas leaks during motor ignition. The first flight of this redesigned ignitor is planned in FY 1993. Two Technical Evaluation Motor (TEM) static test firings will be conducted in FY 1993, with the final TEM firing scheduled in March 1993. SRB project support activities at MSFC needed to support these development efforts will continue. In addition, an asbestos-free program on the RSRM will be initiated which will involve the need to develop and requalify the RSRM with a non-asbestos insulation material.

BASIS OF FY 1993 FUNDING REQUIREMENT

LAUNCH AND MISSION SUPPORT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Launch site equipment (LSE)	101,200	79,400	85,100	86,000
Mission support capability	136,045	190,700	176,600	124,700
Total	237,245	270,100	261,700	210,700

OBJECTIVES AND STATUS

This activity supports the development of launch and mission support capabilities, principally at JSC and KSC.

The major operational Space Shuttle facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC), and three Mobile Launch Platforms (MLPs). These facilities support the prelaunch and post-landing processing of the four orbiter fleet. Key enhancements funded in Launch Site Equipment include: development and implementation of a digital operational intercom system; replacement equipment for the Launch Processing System (LPS); an improved Checkout, Control, and Monitoring System (CCMS II); a Shuttle Processing Data Management System (SPDMS); a Launch Team Training System (LTTS); fiber optic cabling; and the Launch Equipment Test Facility (LETF) support.

The mission support capability budget funds JSC projects to improve capabilities or replace obsolete equipment such as: the Mission Control Center (MCC) equipment upgrade; the flight and ground support training facility improvements; and the flight design systems enhancements. Improvements are being made in simulation training in both the Shuttle Mission Simulator (SMS) and the MCC. SMS upgrades include new host computers, interface hardware and simulator subsystems. The MCC will have improved console operations and communication equipment as well as new data processing and distribution systems. Critical improvements in simulation fidelity will be accommodated with the expanded capacity of the new hardware. Reliability required for the longer integrated simulations, and associated maintenance cost, will also be substantially improved with these replacements.

Other activities funded in mission support capability include implementing required modifications and upgrades on the T-38 proficiency aircraft as well as capability improvements for weather prediction and information handling to improve system monitoring, notably for anomaly tracking.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The Launch and Mission Support total has decreased $8.4 million. Launch Site Equipment (LSE) has increased $5.7 million due to a reassessment of costs to continue the fiber optics cabling as well as a reestimate on the costs to outfit the third orbiter processing facility. Mission support capability has decreased $14.1 million. This is consistent with Congressional direction and it will be accommodated by constraining funding for new requirements.

BASIS OF FY 1993 ESTIMATE

At KSC, the Operational Digital Intercom System (OIS-D) will be completed along with the activation of the Processing Control Center (PCC). The KSC SPDMS II will also be completed in FY 1993. In addition, other necessary upgrades and equipment replacements will be continued. At JSC, training augmentations in the SMS will be completed such as visual upgrades in the fixed and motion base simulators as well as enhancements to the guidance and navigation simulator. The Flight Ascent Design System (FADS) equipment upgrade project, to automate much of the flight design process at JSC, should be completed in FY 1993. The major equipment upgrades in the MCC will continue with the replacement of aging equipment such as the data processing and distribution system. Preliminary planning activities are underway for replacement of major components of the SMS such as the crew station, fixed and motion base simulators, the instructor operating station, and the General Purpose Computer (GPC) interfaces. Other activities and projects will be continued. The decrease in funding from FY 1992 levels is due to the transfer of activities managed by the Orbiter Project and the Space Shuttle Program Office from mission support capability to orbiter operational capability in order to enhance management and control of these activities.

BASIS OF FY 1993 FUNDING RE_ I

ASSURED SHUTTLE AVAILABILITY (ASA)

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Alternate turbopump		79,100	81,900	81,800
(Development)		(79,100)	(63,400)**	(40,000)
(Implementation)		(0)*	(18,500)	(41,800)
Transfer from operations			12,700	
Reestimate of implementation costs.			10,100	
Implementation savings from fuel pump delay			-4,300**	
Multifunction electronic display system		14,800	12,200	21,900
Advanced fabrication engine		23,500	--	--
Hardware interface module replacement.		1,900	3,200	3,600
Cable plant upgrade at KSC		--	300	7,100
Studies/new candidates		3.000	7.000	24.500
Total		122.300	104.600	138.900

* In the FY 1992 budget the costs to implement the Alternate Turbopump on the engine fleet were funded under Shuttle operations at a value of $12.7 million. In the current estimate these were transferred to the Assured Shuttle Availability (ASA) and increased by $10.1 million due to a reestimate of pump prices.

** The decision to delay the development of the fuel pump lowers the development cost by $15.7 million and saves another $4.3 million in implementation costs bringing the total savings to $20.0 million.

OBJECTIVES AND STATUS

In order to assure that the U.S. maintains a viable manned transportation capability into the next century, specific program investments are required. The ASA program, which was initiated in FY 1992, addresses obsolete systems that will become increasingly expensive to operate and maintain. Additional benefits include improving safety and reliability, improving the flight turnaround time, and reducing operational costs. In the past, these kinds of improvements have been added incrementally as individual items of hardware experienced problems or vendors could no longer supply older components. It is apparent that these types of requirements will increase as the Shuttle system ages. The approval process in ASA will ensure that improvements are evaluated and approved on a priority basis across the entire Shuttle program. The ASA will enable the life of the current Shuttle fleet to be extended into the next century. The orbiter vehicle, associated with elements of flight hardware, ground processing facilities, and other supporting systems will be considered in the implementation of this program. The schedule for development and installation of orbiter-related improvements is designed to take advantage of the planned intervals when orbiters are scheduled to be taken out of service for structural inspections and modifications. This plan provides for an orderly development and implementation program and minimizes interruption of the flight program. Specific, large improvements which exceed a total cost of $15.0 million will be funded from ASA. Smaller improvements and modifications will continue to be funded in the individual projects.

The Alternate Turbopumps (ATPs) are state-of-the-art technology designs intended to address the shortcomings of the current SSME high-pressure turbopumps. The ATPs use precision castings, have fewer parts, stiffer shafts and better bearings than the current pumps, and reduce welds from 769 to 7. All uninspectable welds are eliminated. With all of these improvements, the ATPs should provide increased supportability, greater safety margins, and a longer operating life than current pumps. Consistent with direction contained in House Report 102-226, NASA has assessed the merits of continuing development of the alternate fuel pump. It has been concluded that development activities on this fuel pump should be suspended at this time so that effort can be focused on the more critical liquid oxygen (LOX) pump. When the LOX pump is successfully certified for flight, NASA will resume development efforts on the fuel pump. Based on the current schedule this resumption would occur in FY 1994.

The Multifunctional Electronic Display System (MEDS) upgrade will allow replacement of the 1970 display technologies which are embedded in the orbiter cockpit. The current display system, which provides the pilot and commander with vehicle flight control and the interface to the orbiter data processing system, is a single string electro-mechanical system which is proving particularly susceptible to life-related failures. The upgrade will provide both a new architecture and the flight equipment to enhance the reliability of the system and resolve parts availability problems. The upgrade effort includes the design effort and the production of additional modification kits for the four vehicles. New ground support hardware will also be designed, procured, and installed to upgrade the appropriate simulators and laboratories.

Definition efforts on the Advanced Fabrication engine have been terminated based on a reassessment of funding priorities. Specific components of this engine which appear promising such as the large throat main combustion chamber will be reviewed as part of the ASA process.

The Hardware Interface Module (HIM) cards at KSC are obsolete resulting in an increased failure rate and repair cost over the past several years. This upgrade will replace all chassis and cards with state of the art "off the shelf" hardware to improve system reliability and maintainability. The design reviews should be completed in FY 1992 and the procurement will be initiated in FY 1993.

The cable plant upgrade at KSC is being initiated to replace the miles of cables which support a wide variety of Shuttle facilities. Many of these cables were installed in the 1960s, and this upgrade will replace the wideband distribution systems and the lead/antimony sheath cables installed at that time with fiber optics and plastic sheath, gel-filled cable. In addition, many field terminations will be replaced or upgraded along with the manhole system. Other obsolete systems will be replaced with current technology. This will reduce the possibility of launch delays, increase communication system spares availability, and enhance the reliability of data, instrumentation, voice, and video communications.

Studies to examine areas of vulnerability across the Shuttle system and to identify new candidate items will be conducted. When promising candidates are identified, preliminary designs will be developed along with cost estimates and project schedules. Once approved, these new items will be identified as discrete ASA projects.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The ASA budget has been decreased a net of $17.7 million. Delaying work on the alternate fuel pump reduced the estimate by $20 million. However, the ATP program now includes the implementation costs associated with purchasing the required number of pump sets to outfit the engine fleet. These funds had been budgeted in Shuttle Operations at $12.7 million. In addition, these implementation costs had increased $10.1 million prior to delaying the fuel pump development. The MEDS for the orbiter cockpit has been decreased $2.6 million due to a slow start on its development. The advanced fabrication engine was terminated due to overall budget constraints resulting in a savings of $23.5 million. The replacement of the HIM cards at KSC has been rephased. A new item, the cable plant upgrade at KSC, has been identified over the past year and it will be initiated in FY 1992.

BASIS OF FY 1993 ESTIMATE

Alternate Turbopump funding in FY 1993 reflects a substantial reduction over the initial requirements including the fuel pump and is focused on completing development testing of the High Pressure Liquid Oxygen (LOX) pump and initiating certification testing. In FY 1993 the MEDS will conduct its Critical Design Review (CDR). The MEDS prime contractor, along with the subcontractors, will also begin the build of prototype units in preparation for systems integration testing to be started in FY 1994. The HIM card project will have a CDR in FY 1993 for the hardware/software integration and validation. The Request For Proposals (RFPs) will be released and contracts awarded for the first hardware production units to be delivered in FY 1994. The KSC cable plant upgrade will involve design reviews in FY 1993 prior to replacing the cable network running from the Launch Control Center (LCC) to the Launch Pads. The vulnerability studies across all the Shuttle projects will continue. The FY 1992 selection process will prioritize candidates using the vulnerability assessment criteria and initiate only those projects considered mandatory. In addition to the vulnerability studies, there are several studies ongoing focused on the replacement of environmentally restricted materials that will be considered in the ASA process. Currently identified candidates include a simplified OMS/RCS system, long life fuel cells, and orbiter accommodations for the GPS system.

SHUTTLE
OPERATIONS

BASIS OF FY 1993 FUNDING REQUIREMENT

SPACE SHUTTLE OPERATIONS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Flight operations	787,200	912,500	790,300	740,400	SF 2-4
Flight hardware	1,370,000	1,417,000	1,297,100	1,455,300	SF 2-6
Launch and landing operations	595,200	694,100	628,300	639,900	SF 2-8
Research operations support	(266,571)	(300,8931	227,700	279,600*	SF 2-10
Total	2,752,400	3,023,600	2,943,400	3,115,200	
(Expendable launch vehicle services) ..	(229,200)	(341,900)	(195,300)	(217,500)**	

Distribution of Program Amount bv Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Johnson Space Center	781,400	896,800	816,300	904,500
Kennedy Space Center	780,500	907,400	903,800	946,700
Marshall Space Flight Center	1,156,800	1,166,400	1,130,300	1,150,900
Stennis Space Center	2,500	2,400	12,400	12,600
Goddard Space Flight Center	--	--	--	--
Langley Research Center	--	--	--	--
Lewis Research Center	--	--	--	--
Ames Research Center	5,600	6,400	5,900	5,800
Headquarters	25,600	44,200	74,700	94,700
Total	2,752,400	3,023,600	2,943,400	3,115,200

*Research Operations Support reflects the transfer from the Research and Program Management (R&PM) appropriation.

**ELV launch services, previously funded under the Office of Space Flight, has been officially transferred to the Office of Space Science and Applications. See Page 3-1 for a discussion of ELV resource requirements.

OBJECTIVES AND STATUS

Space Shuttle Operations provides launch services to NASA payloads. Shuttle services are also provided, on a reimbursable basis, to the Department of Defense, other civil agencies, and certain commercial and international users. The Shuttle launch schedule is based on eight flights per year through FY 1996 and nine flights per year following the Space Station Man Tended Capability (MTC).

The Space Shuttle has demonstrated a broad range of capabilities including deployment of spacecraft and their upper stages, satellite repairs, satellite retrieval, operations using the remote manipulator, integral scientific experimentation using Shuttle and Spacelab systems, and extravehicular activity operations. These capabilities provide a unique national resource that enhances the scientific reward of many payloads. The major program elements of Shuttle Operations are Flight Operations, Flight Hardware, Launch and Landing Operations, and Research Operations Support. These elements provide for the standard service operation of the Shuttle, including preflight preparation activities, procurement and refurbishment of flight hardware, and maintenance and operation of equipment and facilities necessary to support all phases of the Shuttle flight process.

The Flight Operations activity is divided into three major elements: mission operations, integration, and support. Mission operations includes training, flight operations activities, aircraft operations, and a wide variety of planning activities ranging from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Integration includes cargo analytical integration, systems integration, and other tasks managed by the Space Shuttle Program Office. The support element includes flight software development as well as other support activities at JSC. Shuttle system support for program and integration activities at the Marshall Space Flight Center, Kennedy Space Center, and the Stennis Space Center are also included.

The Flight Hardware program element provides for: the procurement of external tanks (ETs) and solid rocket booster (SRB) elements including motors, booster hardware, and solid propellants; orbiter logistics support; replenishment of the orbiter spare parts inventory; SSME component repairs and overhauls; SSME anomaly resolution activities; orbiter and crew equipment; ET disconnects; orbiter sustaining engineering; and flight crew equipment maintenance and operations. Included in the funding request for tanks and boosters are the long-lead raw materials, subassemblies, and subsystems needed to deliver hardware in a manner consistent with flight rate requirements.

Launch and Landing Operations provides launch preparation, liquid propellants and gases, prelaunch and post-landing operations for the Shuttle and its cargo.

Research Operations Support funding provides vital support to the civil service workforce and to the physical plant at the centers and at NASA headquarters. This support was previously funded as Operations of Installation in the Research and Program Management (R&PM) appropriation.

Shuttle funding beginning in FY 1992 incorporates annual efficiencies and anticipated cost reductions totalling 3 percent per year resulting in a 15 percent annual savings by FY 1996. In FY 1993 these savings total over $200 million against the previously planned budget runout levels and are based on a combination of specific content changes and management challenges agreed to by the various Shuttle project offices and contractors. In FY 1992 internal estimates of Shuttle operations requirements exceed the current availability. As the year progresses we will carefully monitor the funding levels to ensure that operations are not adversely impacted by lack of resources.

As in the past, Shuttle Operations requirements are funded through a combination of appropriations and reimbursements received from customers manifested on the Shuttle. In FY 1992, NASA plans $106.6 million of reimbursements. In FY 1993, only $45 million of reimbursements will be released which results in additional appropriations required over FY 1992 levels. This is due to a fewer number of customers being flown.

The FY 1993 request for Shuttle Operations, excluding Research Operations Support, is $119.9 million higher than the FY 1992 operating plan level. This is the net result of several factors. The drop in reimbursements together with the possible shortfall in FY 1992 would result in an increase of about $160 million. In addition, normal escalation from FY 1992 to FY 1993 would raise this expected increase over the current FY 1992 level to about $250.0 million; however, the Shuttle Operations cost reduction targets increase from FY 1992 to FY 1993, effectively offsetting the escalation increase and limiting the overall growth to $119.9 million.

BASIS OF FY 1993 FUNDING REQUIREMENT

FLIGHT OPERATIONS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Mission operations	275,000	318,800	260,400	338,400
Integration	317,900	342,300	315,400	163,000
Support	194.300	251.400	214,500	239,000
Total	787,200	912,500	790,300	740.400

OBJECTIVES AND STATUS

Flight operations is divided into three major areas of activity: mission operations, integration, and support. Mission operations includes a wide variety of preflight planning, crew training, and operations control activities. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include: flight planning; preparing systems and software handbooks; defining flight rules; creating detailed crew activity plans and procedures; developing and establishing the Mission Control Center (MCC) and network system requirements for each flight; and contributing to planning for the selection and operation of Shuttle payloads. Flight planning encompasses flight design, flight analysis, and software activities. Both conceptual and operational flight profiles are designed for each flight and the designers also help to develop crew training simulations and flight techniques. In addition, the flight designers must develop unique, flight-dependent data for each mission. The data is stored in the erasable memories located in the orbiter, shuttle mission simulator, and MCC computer systems. Mission Operations funding also provides for the maintenance and operation of critical mission support facilities including the MCC, flight simulators, crew training, and flight software support facilities. Finally, mission operations now includes maintenance and operations of aircraft needed for flight training and crew proficiency requirements.

Integration includes payload integration into the Shuttle and system integration of the flight hardware elements. Support includes flight software development and verification. The software activities include development, formulation, and verification of the guidance, targeting, and navigation systems software in the orbiter. Support also includes base operations support to Shuttle operations and systems level support at the manned space flight centers.

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CHANGES FROM FY 1992 BUDGET EST___TE

FY 1992 funding for the Flight Operations budget decreased $122.2 million. Operations targets agreed to by the Shuttle projects account for $26.1 million of this decrease. As a result of manifest changes and the flight rate reduction to 8 per year, funding requirements have declined another $19.5 million. Another $54.1 million has been deleted based on controls on anticipated change traffic. The remaining target amount of $22.5 million has not yet been determined and is part of the unresolved funding issues outstanding in FY 1992.

BASIS OF FY 1993 ESTIMATE

The Flight Operations portion of the Shuttle Operations budget continues to support that activity predominately associated with the effort at JSC to plan for and conduct Shuttle missions from launch to landing. The functions are essentially the same as in the past: to maintain and operate all the ground facilities necessary for flight preparation and execution; to instruct the flight and ground controller crews; to maintain and operate aircraft for proficiency, training and orbiter ferry requirements; and to perform analyses of and conduct the mission planning necessary for each mission. The eight missions to be flown in FY 1993 and initial efforts for flights in FY 1994 and FY 1995 will be supported. Flight Operations also funds the sustaining engineering required to integrate all flight and ground elements and to assure systems safety and integrity. Funding for the analytical integration of the payloads into the orbiter and the planning to assure compatibility and certification of interfaces is included. Crew operations and training programs are also supported. Functions such as aircraft operations and JSC engineering for the Shuttle will be continued.

Beginning in FY 1993 mission operations will consolidate all operations tasks managed by the Mission Operations Directorate (MOD) and the Flight Crew Operations Directorate (FCOD) at JSC. The FCOD activities are being added to mission operations since they are primarily related to crew training which is an essential element of this line item. These tasks had been previously funded under support. Orbiter sustaining engineering is being transferred from integration and will now be included under orbiter flight hardware. In this way, all sustaining engineering for the flight hardware elements will be aligned with their flight hardware budgets. In addition, flight software development and certification will be included under support rather than in integration. The resulting integration budget only includes operational tasks managed by the Space Shuttle Program Office.

In total, the FY 1993 funding for flight operations is lower than the current estimate in FY 1992 primarily due to the transfer of $116.0 million for orbiter sustaining engineering to orbiter flight hardware.

BASIS OF FY 1993 FUNDING REQUIREMENT

FLIGHT HARDWARE

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Orbiter	414,500	441,700	390,400	522,700
Solid rocket booster (SRB)	577,400	592,400	541,300	556,700
External tank (ET)	378.100	382.900	365.400	375.900
Total	1.370.000	1.417.000	1.297.100	1.455.300

OBJECTIVES AND STATUS

The Flight Hardware program element provides operational support to the orbiter, funds the manufacturing and refurbishment of Solid Rocket Booster (SRB) and Redesigned Solid Rocket Motor (RSRM) hardware, and procures External Tanks (ETs).

Orbiter operational support includes the following: Orbiter spares for the replenishment of Line Replacement Units (LRUs) and Shop Replacement Units (SRUs); manpower to support the orbiter logistics program; procurement of ET disconnects; repair of orbiter flight hardware; orbiter sustaining engineering beginning in FY 1993; overhaul of Space Shuttle Main Engine (SSME) components; procurement of SSME spare parts; manpower for SSME flight support and anomaly resolution; flight crew equipment processing; flight crew equipment spares and maintenance; and other miscellaneous orbiter support items.

Included in the funding request for tanks and boosters are the long-lead raw materials, subassemblies, and subsystems necessary to sustain the production of these elements in a manner consistent with the flight rate. Production phasing of these elements is based on the current flight traffic model and is structured to maintain a smooth and efficient buildup of the production capability. In the ET, production continues at the minimum level of activity necessary to retain manufacturing capability until the existing inventory of tanks is reduced to an operational level.

CHANGES FROM FY 1992 BUDGET ESTIMATE

In total, Flight Hardware funding has decreased $119.9 million. Operations targets placed on these hardware projects account for $36.9 million of this reduction. Flight savings due to the reduced traffic model save $23.8 million. The transfer of the implementation costs on the Alternate Turbopump to the Assured Shuttle Availability (ASA) line results in another $12.7 million decrease. The balance of the reduction will be monitored to ensure that adequate resources are provided to support Shuttle operations.

BASIS OF FY 1993 ESTIMATE

Requirements for orbiter flight spares, crew equipment spares, and logistics are based on projected flight rates, maintenance schedules, operational usage, repair times, and lead times to procure or repair flight hardware. The budget provides replenishment line and shop replaceable units, as well as the manpower to support the overhaul and repair activity for the orbiter, extravehicular maneuvering unit and other crew equipment. The flight equipment processing contract (FEPC) is continued to support the projected flight schedule. Main engine hardware provides for manufacturing and delivery of overhauled engines and engine component spares as well as for flight support and anomaly resolution. Flight hardware requirements for the SRB and ET include the procurement of the materials and labor required to support flights during FY 1993 as well as flights planned in FY 1994 and FY 1995.

Funding in FY 1993 is $158.2 million above the current estimate for FY 1992 primarily due to the transfer of orbiter sustaining engineering from Flight Operations. This accounts for $116 million of the increase and it will consolidate orbiter sustaining engineering with the hardware procurement which is consistent with all the other flight hardware projects.

BASIS OF FY 1993 FUNDING REQUIREMENT

I AND LANDING OPERATIONS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Launch operations....................	539,200	629,300	567,500	581,100
Payload and launch support............	56.000	64.800	60.800	58.800
Total.............................	595.200	694.100	628.300	639.900

OBJECTIVES AND STATUS

Launch and Landing Operations provides for the manpower and materials to process and prepare the Shuttle flight hardware elements for launch as they flow through the processing facilities at KSC. Standard service processing and preparation of payloads as they are integrated into the orbiter are also funded under this category as is procurement of liquid propellants and gases for launch and base support. Support to landing operations at KSC, Edwards Air Force Base (EAFB) and contingency sites, as required, is also provided.

Operation of the launch and landing facilities and equipment at KSC involves refurbishing the orbiter, stacking, and mating of the flight hardware elements into a launch vehicle configuration, verifying the launch configuration, and operating the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation, and inventory management.

In addition, this budget includes other launch support services: the central data subsystem, which supports Shuttle processing as an on-line element of the launch processing system, is maintained and repaired; Shuttle related data management functions such as work control and test procedures are funded; equipment, supplies and services are purchased; and operations support functions are paid for. Among these support functions are propellant processing, life support systems maintenance, railroad maintenance, pressure vessel certification, Shuttle landing facility upkeep, and equipment modifications.

Payload and launch support funding provides propellants for payload launch operations and base support, and contractor support for the assembly of individual payloads into a total cargo. This element includes providing launch site support managers to payload customers and verifying cargo-to-orbiter interface. Operations maintenance and logistic support is provided to cargo support equipment (such as cargo integration test equipment and multimission payload support equipment) and to the payload support areas (the Vertical Processing Facility, Operations and Checkout building, and cargo hazardous servicing facilities). Support required for maintaining the Dryden Flight Research Facility as a contingency landing site is also included.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Funding requirements for Launch and Landing Operations reflect a decrease of **$65.8** million. Operations targets result in a reduction of $17.1 million while flight savings due to the reduced traffic model account for another $12.7 million. A management plan to control anticipated changes results in a reduction of $18.1 million. The remaining target amount is an unresolved reduction which will be worked out during the operating year.

BASIS OF FY 1993 ESTIMATE

Launch operations funding in FY 1993 provides manpower and support services necessary for processing launches from **KSC**. This includes manpower to assemble the SRBs, mate the boosters and tanks, process the orbiter, mate the orbiter to the integrated SRBs and tank, process and checkout integrated flight elements through launch, retrieve and disassemble the **SRBs** for refurbishment, and support landing of the orbiter either at **KSC**, at EAFB, or at a contingency landing site when required. Funding also supports the manpower required for **KSC** sustaining engineering, provisioning, logistics, launch processing system operation and maintenance, and maintenance/ modification of all other Shuttle-related ground support equipment and facilities. Flight safety will continue to be emphasized through testing, engineering and quality control.

The increase in FY 1993 required over FY 1992 is primarily due to the drop in planned reimbursements. This increase is partially offset by the Shuttle Operations cost targets in FY 1993 which are greater than in FY 1992.

BASIS OF FY 1993 FUNDING REQUIREMENT

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Research operations support...........	(266,571)	(300,893)	227,700	279,600

OBJECTIVES AND STATUS

Research and operations support funding provides vital support to the civil service workforce and to the physical plant at the centers and at NASA headquarters. Support to the civil service workforce includes provision of the basic tools to work productively such as telephone and mail service, office supplies, equipment and furniture, and the basic photo, printing and graphics shops. Support to the physical plant includes payment for center utilities, rental of buildings and space, and necessary fire protection, janitorial, and security services. Support to the physical plant also includes maintenance of roads and grounds and the maintenance of general purpose facilities such as administrative buildings and the extensive utilities systems.

CHANGES FROM FY 1992 BUDGET ESTIMATE

In FY 1992 and previously, these activities were funded in the Research and Program Management (R&PM)/Operation of Installation appropriation. FY 1992 Congressional action both sharply reduced the requested funding for these activities, shown in parenthesis, and authorized their transfer into the Research and Development (R&D) and Space Flight Control and Data Communications (SFCDC) appropriations. This transfer has allowed the reduction to be accommodated with minimum impact by allowing the programs to fund some of the activities that had previously been covered by these funds.

BASIS OF FY 1993 ESTIMATE

NASA is in the process of deciding exactly how the activities previously budgeted in the Operation of Installation account will be budgeted in future years. The FY 1993 estimate represents the amount required to provide the basic minimum institutional support, and it will be necessary to develop mechanisms that either allow this estimate to be supplemented by program funds or that incorporates some of the funding for these activities in the program budgets.

EXPENDABLE
LAUNCH VEHICLES

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

EXPENDABLE LAUNCH VEHICLES

EXPENDABLE LAUNCH VEHICLES AND SERVICES

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Small class	14,100	33,700	33,100	27,900	SF 3-2
Medium class	97,300	81,500	61,100	67,300	SF 3-2
Intermediate class	108,100	156,500	85,000	54,800	SF 3-2
Large class	9,700	70,200	16,100	11,000	SF 3-2
Upper Stages (IUS/TOS/IPS)	(82,500)*	(108,500)*	(62,300)*	56,500	SF 3-2
Total	229,200	341,900	195,300	217,500	

*A non-add. Upper Stages was funded under STS Capability Development prior to FY 1993.

Distribution of Proeram Amount Bv Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Kennedy Space Center	5,400	6,200	8,800	7,300
Marshall Space Flight Center	--	--	--	55,400
Goddard Space Flight Center	105,100	100,900	106,000	78,800
Lewis Research Center	117,200	219,000	61,000	62,600
Headquarters	1,500	15,800	19,500	13,400
Total	229,200	341,900	195,300	217,500

OBJECTIVES AND STATUS

The Expendable Launch Vehicles (ELV) services program provides a mixed fleet capability, which in conjunction with the Space Shuttle, satisfies NASA payload requirements. Payloads are assigned for launch on ELVs consistent with Shuttle use criteria established in NASA's FY 1991 Authorization Act and the Launch Services Purchase Act of 1990. As part of NASA's launch recovery strategy following the Challenger accident, four scientific spacecraft configured for launch on the Shuttle were transitioned to ELVs. The ELVs for these missions were selected non-competitively. Two of these missions were launched successfully in 1990: the NASA/German cooperative Roentgen Satellite (ROSAT) in June on an USAF procured Delta II; and the NASA/USAF Combined Release and Radiation Effects Satellite (CRRES) on the first commercial Atlas I, procured through an exchange of residual NASA assets for the launch service. Funding was provided for the procurement of a Delta II vehicle and launch services through the DOD (under the Quid Pro Quo arrangement) for the Extreme Ultraviolet Explorer (EWE) mission to be launched in May 1992. Funding was also included for Titan III launch services to support the Mars Observer (MO) spacecraft which is scheduled to be launched in September 1992.

All subsequent ELV launch services are being acquired by NASA competitively from the private sector, whenever available, to launch civil government payloads in three performance classes: (a) small class capable of launching payloads up to 1,000 lbs. in low Earth orbit, (b) medium class capable of launching payloads up to 10,000 lbs., and (c) intermediate class capable of launching payloads up to 30,000 lbs. Large class missions with payloads up to 40,000 lbs. to low Earth orbit must be acquired through the DOD since no commercially provided launch services are currently available for this size payload. Beginning in FY 1993, funding required for Upper Stage vehicles is included under the SFCDC/ELV budget line since they are expendable and directly support either a Shuttle or an ELV payload.

In September 1991, a contract with Orbital Sciences Corporation (OSC) was signed to provide Small Expendable Launch Vehicle (SELV) services using the Pegasus vehicle. In November 1990, a contract with McDonnell-Douglas was signed to provide Medium Expendable Launch Vehicle (MELV) services using the Delta II vehicle. A competitive request for proposal is targeted for release in 1992 to cover a series of potential Intermediate Expendable Launch Vehicle (IELV) missions. These potential missions include the Advanced Tracking and Data Relay Satellite System (TDRS II), the Geostationary Operational Environmental Satellite (GOES), and the Earth Observing System (EOS) as well as international cooperative missions. Large class ELVs are procured through the Air Force since Titan IV vehicles are not available from the private sector.

CHANGES FROM FY 1992 BUDGET ESTIMATE

Funding for ELVs has decreased $146.6 million in FY 1992. For the SELVs, funding was reduced as a result of the selection of the Pegasus vehicle from OSC and the renegotiation of the Scout contract for the launch of the Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX) mission. MELV estimates decreased due to the delay of the Radarsat mission to December 1994 partially offset by the addition of payloads to be launched from the East Coast on DOD Delta-I1 flights. In the Intermediate vehicle class, funding for an ELV for TDRS-7 was deleted per Congressional direction and the payload assigned to the Shuttle. NASA's contribution to the launch of the Mobile Satellite (MSAT) mission has been terminated and all ELV funding has been deleted. The balance of the decrease in the Intermediate class is due to a change in the commercial payment schedule for the Atlas IIAS vehicle to be used to launch the international cooperative Solar and Heliospheric Observatory (SOHO) mission as well as changes in the Titan III estimates for the MO mission and other schedule adjustments. Large class ELVs have decreased due to the deferral of the Cassini launch to October 1997 thereby reducing the funding requirements for its Titan IV/Centaur vehicle.

BASIS OF FY 1993 ESTIMATE

In FY 1993, funding is required for SELVs in order to support the launch of the Total Ozone Mapping Spectrometer (TOMS) in 1993. Other missions being supported with SELV funds are the Fast Auroral Snapshot explorer (FAST) to be launched in 1994, the Satelite de Applicaciones Cientificas-B (SAC-B)/High Energy Transient Experiment (HETE) scheduled for a launch in late 1994, and the Submillimeter Wave Astronomy Satellite (SWAS) scheduled for a 1995 launch. NASA, in cooperation with the German Space Agency, intends to exchange a set of Scout launch vehicle hardware in NASA's inventory for the scientific data from the Equator-S spacecraft being developed by the Max Planck Institute. The Scout will be modified through an agreement between NASA and both the German and Italian Space agencies. No appropriated funds for launch services are required in this barter agreement.

Funding for launches utilizing MELVs in FY 1993 are the Wind and Polar missions to be launched in 1993/1994. Funding will be continued for the Radarsat mission to be launched in 1994 and a new mission, the X-ray Timing Explorer (XTE) to be launched in 1996, is now included. This mission was transitioned from launch on the Shuttle to a Delta II ELV. The integration for three secondary payloads to be launched from the East Coast on DOD Delta-I1 vehicles is funded as well. Finally, funding is included to initiate procurement of MELV services for the Lunar Resources Mapper (LRM), a small, robotic, lunar precursor mission in support of the Space Exploration program scheduled for launch in 1995.

Most of the funding required in FY 1993 for the Intermediate class is for an Atlas-IIAS in support of the SOHO mission to be launched in 1995. The balance of funding is needed to initiate procurement and continue leading edge integration on vehicles to support the TDRS-II whose launches are scheduled beginning in FY 1997. The EOS missions are being restructured for launch aboard smaller ELVs. The EOS-AM-1 mission to be launched in 1998 has been scaled down from a Titan IV to an IELV. A small amount of funding will be used to support leading edge vehicle analyses and integration efforts.

Large class ELV funding is needed for a Titan IV vehicle to support the Cassini mission scheduled for launch in October 1997. Since the Centaur upper stage is purchased through the DOD along with the Titan IV vehicle as an integral launch system, the funding for this stage is included as part of the ELV estimate and is not separately budgeted.

Beginning in FY 1993, the Inertial Upper Stage (IUS) and the Transfer Orbit Stage (TOS) are funded in the ELV budget line. These items were previously funded as part of the Space Transportation Capability Development budget. The IUS funding in FY 1993 completes the procurement of the IUS vehicle to support the TDRS-6 mission scheduled for a Shuttle launch in FY 1993. In addition, funding is included for an IUS vehicle for the TDRS-7 mission to be launched on the Shuttle in 1995 in accordance with Congressional direction. TOS funding in FY 1993 is for completing the procurement of the TOS vehicles needed to support the Mars Observer (MO) mission to be launched on a Titan III in September 1992 and the Advanced Communications Technology Satellite (ACTS) to be launched on the Shuttle in 1993. In the future, upper stages required for ELV launches will be funded and procured under the particular ELV performance class while any upper stage to be used on a Shuttle launch will be included under this category. In the absence of an ASRM, it will be necessary to procure an Integral Propulsion System (IPS) to support the Advanced X-ray Astronomy Facility (AXAF) scheduled for a Shuttle launch in 1999. The IPS is needed in order to obtain the required 320 nautical mile circular orbit.

SPACE
COMMUNICATIONS

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1993 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS

SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS

SUMMARY OF RESOURCES REQUIRED

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space network..	310,100	347,973	353,875	298,200	SF 4-4
Ground networks..	260,700	291,700	283,000	314,600	SF 4-11
Communications and data systems.......	257.989	314.200	281.400	308.200	SF 4-20
Total.	828.789	953,873	918.275	921.000	

Distribution of Pronram Amount bv Installation

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
Ames Research Center..................	13,000	14,500	13,000	16,100
Goddard Space Flight Center...........	569,080	614,900	595,400	607,800
Headquarters..	41,945	76,273	74,875	46,500
Jet Propulsion Laboratory.............	147,799	180,800	177,800	186,100
Kennedy Space Center..................	--	--	700	--
Langley Research Center...............	130	--	--	--
Lewis Research Center.................	1,060	1,400	200	200
Marshall Space Flight Center..........	55.775	66.000	56.300	64,300
Total.	828.789	953.873	918.275	921.000

OFFICE OF SPACE COMMUNICATIONS **SPACE AND GROUND NETWORKS. COMMUNICATIONS AND DATA SYSTEMS**

OBJECTIVES AND JUSTI ICAT

The purpose of this program is to provide the vital tracking, telemetry, command, data acquisition, communications, and data processing required by all NASA flight projects. Some of these capabilities are provided on a reimbursable, noninterference basis to projects of other Government agencies, commercial firms, and international organizations.

These capabilities are provided to meet the requirements of NASA's Earth orbital, planetary and solar system exploration spacecraft missions, research aircraft, sounding rockets and balloons. Included in Earth orbital activities are the Space Transportation System (STS), Spacelabs, and scientific and applications missions. The various capabilities provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of science and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) reception of television transmissions from space vehicles; (e) transmissions of commands from ground facilities to the spacecraft; (f) voice communications with astronauts; (g) transfer of information between the various ground facilities and control centers; and (h) processing of data acquired from the launch vehicles and spacecraft. These capabilities are essential for operating and maintaining U.S. space assets to achieve the scientific objectives of all flight missions and for executing the critical decisions necessary to the success of these missions.

NASA has three separate tracking networks to meet the requirements of NASA flight missions. These are: the Spaceflight Tracking and Data Network (STDN), for launch vehicles including STS launch and landing operations; the Deep Space Network (DSN), for planetary and interplanetary flight missions, high Earth orbital missions, and low Earth orbital missions that are unable to communicate through the Space Network; and the Space Network, which includes the Tracking and Data Relay Satellite System (TDRSS) and is required by most low Earth orbital missions. The Space Network and STDN are managed by the Goddard Space Flight Center (GSFC). The DSN is managed by the Jet Propulsion Laboratory (JPL).

NASA has two communications networks; NASA Communications (NASCOM), which is managed by the GSFC, and the Program Support Communications Network (PSCN), which is managed by the Marshall Space Flight Center (MSFC). The NASCOM interconnects the tracking networks with the spacecraft control centers and data processing facilities associated with each mission. This network provides three classes of service: a relatively low data rate system for the launch and landing facilities at the Kennedy Space Center (KSC) and the Dryden Flight Research Facility (DFRF); a medium rate system for the DSN; and a high rate system for the Space

Network. The PSCN provides computer networking, voice and video conferencing, facsimile and electronic mail to all NASA programs and projects. The network interconnects all NASA locations and selected contractor sites via wideband terrestrial and satellite facilities.

Highly specialized computation facilities provide real-time information for mission control and data processing of the scientific, applications, and engineering data which flow from flight projects. In addition, instrumentation facilities are utilized for sounding rocket and balloon launchings and flight testing of aeronautical research aircraft.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The current estimate of **$918.3** million for **FY 1992** is **$35.6** million below the budget request and is consistent with Congressional action. This funding level includes a **$32.8** million reduction to Communications and Data Systems, which was achieved mainly by combining the Customer Data and Operations System (CDOS) with the Earth Science and Applications/Earth Observing System Data Information System (EOSDIS) program and reducing the Advanced X-ray Astrophysics Facility (AXAF) requirements due to a launch delay. Other changes include an $8.7 million reduction in Ground Networks, which was accommodated by reducing Cassini requirements based on a launch slip and by deferring some other activities. The FY **1992** budget also reflects a **$5.9** million increase to the Space Network to support additional requirements in the TDRSS Replacement and the Second TDRSS Ground Terminal programs, which were partially offset by deferring the start of development in the TDRS II program (formerly designated Advanced TDRSS).

BASIS OF FY 1993 ESTIMATE

The FY **1993** budget reflects an increasing level of flight programs plus the development and implementation activities to meet future mission requirements. A significant portion of the budget is driven by the requirements of operational spacecraft. Among these spacecraft are Galileo; Magellan; Mars Observer, which is scheduled for launch in September **1992;** Hubble Space Telescope (HST); Ulysses; the Cosmic Background Explorer (COBE); the Gamma Ray Observatory (GRO), which has been recently renamed the Compton Observatory; the Upper Atmosphere Research Satellite (UARS); Pioneer spacecraft; Voyager spacecraft; and the Shuttle missions. Funds are also required in FY **1993** to support approved missions currently under development. During FY **1993,** the Tracking and Data Relay Satellite (TDRS) F-6 will be launched, integration and test activities will continue on the replacement spacecraft F-7, and the Second TDRSS Ground Terminal (STGT) will be installed and checked out. The design and development contract for the TDRS II follow-on program is planned for award in early FY **1993** in order to meet requirements in the later half of this decade.

BASIS OF FY 1993 FUNDING REQUIREMENT

SPACE NETWORK

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Tracking and data relay satellite system (TDRSS)	54,700	82,773	80,375	46,200
Space network operations	36,347	46,500	44,900	61,900
Systems engineering and support	36,496	51,700	48,000	59,900
TDRS replacement spacecraft	51,889	34,200	43,900	10,800
Second TDRSS ground terminal	103,898	118,000	130,200	44,500
TDRS II	26.770	14.800	6.500	74.900
Total	310.100	347.973	353.875	398.200

OBJECTIVES AND STATUS

The Space Network consists of the Tracking and Data Relay Satellites (TDRS) and the associated ground elements necessary to meet the requirements of Earth orbital spacecraft missions. The current TDRS constellation consists of two fully functional satellites (one of which has loss of system redundancy) and two partially degraded satellites. One of the partially degraded satellites is operated to reduce schedule overloads during Shuttle missions, and the other is for emergency backup. The ground facilities are located in White Sands, New Mexico. Satellite and ground communication links interconnect the White Sands facilities with the Network Control Center (NCC) at GSFC and other spacecraft mission facilities.

The FY 1993 request includes funding for: maintenance and operations of the White Sands complex; the NCC; systems engineering and mission planning; equipment modification and replacement; initiation of the TDRS II follow-on relay satellite program; continued development of the replacement spacecraft; the continued development of the second ground terminal and the modernization of the first ground terminal.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system (TDRSS)	54,700	50,100	47,700	46,200
Federal finance bank payment	--	32,673	32,675	--
Total	54,700	82,773	80,375	46,200

OBJECTIVES AND STATUS

The TDRSS serves as the communication link between the spacecraft operating in Earth orbit and ground facilities. The TDRS provides space-to-space communications with the orbiting spacecraft and relays data to the White Sands ground facilities which are interconnected with control centers and other facilities.

Through FY 1993, the Space Network will have provided data communications to the Shuttle missions, including Spacelabs; and orbiting satellite missions such as the Earth Radiation Budget Satellite (ERBS), Landsat, the Cosmic Background Explorer (COBE), the Hubble Space Telescope (HST), the Compton Observatory, Upper Atmosphere Research Satellite (UARS), Extreme Ultraviolet Explorer (EWE), and Topography Experiment (TOPEX).

With the successful launch in August 1991, TDRS-5 has been added to the orbital constellation. The TDRS-4 and TDRS-5 are fully functional, with one positioned in the west and the other in the east. The TDRS-1, a partially degraded spacecraft, is utilized to reduce schedule overloads during Shuttle missions; and, TDRS-3 with its reduced service capability, is an on-orbit emergency backup. The TDRS-6 is scheduled for a Shuttle launch in FY 1993.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $2.4 million reflects program savings which were achieved mainly as a result of contract negotiations due to the acceleration of the TDRS-6 contract.

BASIS OF FY 1993 ESTIMATE

During FY 1993, TDRS-6 will be launched and satellite checkout activities will be conducted. Operations and maintenance activities will continue at the White Sands complex.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Space network operations	36,347	46,500	44,900	61,900

OBJECTIVES AND STATUS

The primary objective of Space Network Operations is to provide for the operation and maintenance of the ground systems and facilities required to schedule, control and operate the network system. This network operations system provides the planning, training, staffing, and preparation for upcoming missions necessary to assure operational network capability required by the space missions in Earth orbit.

The NASA Ground Terminal (NGT) at White Sands monitors TDRSS performance, provides fault isolation monitoring for the network, and serves as the communications interface with all other facilities. The Network Control Center (NCC) at GSFC manages and schedules TDRSS services for all user spacecraft.

This activity includes operation of the Flight Dynamics Facility (FDF) which provides orbit determination, mission acquisition computations, and position determination products. In FY 1993, operations costs for the Second TDRS Ground Terminal (STGT) are transferred from the STGT project to Space Network Operations.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $1.6 million reflects the program adjustments that are being made to accommodate a portion of the general reductions specified by Congress. This was accomplished through reductions in the FDF, NGT and NCC.

BASIS OF FY 1993 ESTIMATE

The requested funding provides for the operation of Space Network facilities 24 hours per day, seven days per week, and for related hardware and software maintenance. Funding is also provided for a variety of activities such as operational analysis, mission planning, simulations, compatibility testing, and documentation for missions requiring Space Network capabilities in FY 1993 and subsequent years. Funds for STGT operations begin in FY 1993 with operator training beginning early in the fiscal year and initial operating capability scheduled for the summer.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Systems engineering and support	36,496	51,700	48,000	59,900

OBJECTIVES AND STATUS

The objective of Systems Engineering and Support is to provide the engineering services, hardware, and software development required to sustain and modify the Space Network elements. Systems engineering is supplied primarily through support service contracts. These contracts provide for equipment design and replacement, logistics, and specialized maintenance and operations activities including configuration management and procedure development. Ongoing activities include network integration and test, systems reliability analyses, test equipment procurement, and software modifications required for reliable spacecraft operations and to meet the requirements of missions such as the EWE, UARS, the TOPEX and the Compton Observatory.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $3.7 million reflects a program adjustment required to accommodate a portion of the general reduction specified by Congress. This was accomplished mainly by reducing the Space Station Freedom (SSF) related activities once the SSF data processing and communication requirements were simplified as a result of the restructuring activity.

BASIS OF FY 1993 ESTIMATE

Funds are requested to provide systems engineering, hardware and software maintenance, sustaining engineering, test equipment, and vendor services for specialized equipment and Space Network subsystems. Funding is needed for NCC software development and hardware implementation required for the new interface with the STGT, scheduled for initial operations in FY 1993. Design study activities for the Space Network Control Center, required to replace the NCC with new architecture and technology for low cost maintenance and operations, and to provide network control during the TDRS II era, will be completed in FY 1993.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
TDRS replacement spacecraft	51,889	34,200	43,900	10,800

OBJECTIVES AND STATUS

The objective of this program is to provide the TDRS-7 spacecraft which is required to maintain the TDRS constellation. This spacecraft is functionally identical to the previous six satellites. Design changes have been made to improve reliability and to accommodate subsystems and parts that are no longer being produced. Hardware deliveries will continue in FY 1992 with final delivery of the solid-state power amplifiers delayed until FY 1993. Integration and test activities will continue in FY 1992.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The increase of $9.7 million reflects an unexpected development problem with new power amplifiers for TDRS-7. New amplifiers were required due to obsolescence and reliability concerns with the travelling wave tube amplifiers used in the previous TDRS. Integration and test activities for spacecraft and payload subsystems and software checkout will continue in FY 1992.

BASIS OF FY 1993 ESTIMATE

The requested funds will continue spacecraft and payload subsystem integration and test activities through FY 1993. TDRS-7, which will be launched in FY 1995, is planned for launch on the Shuttle, consistent with Congressional direction.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Second TDRSS ground terminal (STGT) ...	103,898	118,000	130,200	44,500

OBJECTIVES AND STATUS

The objectives of the STGT program are: to eliminate the Space Network's critical single point of failure at the existing ground terminal at White Sands, New Mexico; to upgrade the existing ground terminal for more reliable and more cost effective operations; and to provide additional capability that allows continued use of partially failed spacecraft; and to provide the capability of performing ground terminal maintenance and modifications while maintaining Space Network operations.

The majority of first article hardware has been delivered to the test berth, and hardware/software integration is well underway. As integration of hardware and software is completed, equipment is assembled into subsystems. Once subsystems have been integrated, the subsystem tests are conducted to validate the hardware and software functionality. Upon completion, systems level testing will be conducted at the Space-to-Ground Link Terminal (SGLT) level, currently scheduled to begin in February 1992. At the White Sands site, the 19-meter antennas have completed acceptance testing, and cabling and computer hardware installation is underway in preparation for FY 1993 on-site activities.

CHANGES FROM FY 1992 ESTIMATE

The increase of $12.2 million reflects hardware and software development delays. These delays have impacted assembly and test schedules, and resulted in increased costs.

BASIS OF FY 1993 ESTIMATE

Once system tests are completed, currently scheduled for July 1992, equipment will be shipped to the White Sands location for installation and on-site checkout. While current program emphasis remains on the test and validation of the first SGLT, manufacturing and subcontract activities for the subsequent SGLTs continue and will be ongoing throughout FY 1993. At the STGT site, FY 1993 activities will include station-level validation testing with three SGLTs and integration and testing with other network systems.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite (TDRS) II	26,770	14,800	6,500	74,900

OB AND STATUS

The objective of the program is to design, develop, and competitively procure improved relay satellites required for continuity of Space Network operations. By the late 1990's, the initial block of TDRS satellites will be exhausted. Maintaining the TDRS II delivery schedule is required to ensure continuity of Space Network operations capability required by Earth orbiting satellites. The TDRS II will enable continuation of the Space Network capability into the 21st century. Activity required during FY 1992 will concentrate on defining the interfaces and changes to the Ground Network systems for the TDRS II era.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $8.3 million is due to a delay in starting the TDRS II development contract. Contract award was planned for September 1992 and is now anticipated in early FY 1993.

BASIS OF FY 1993 ESTIMATE

The requested funding will provide for preliminary design, development of contractor work packages, contractor make/buy studies and negotiated subcontracts. This funding is required in order to maintain a schedule commensurate with the need date of June 1997 for the first TDRS 11. This schedule must be maintained to ensure uninterrupted Space Network operational services to flight missions.

BASIS OF FY 1993 FUNDING REQUIREMENT

GROUND NETWORKS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network systems implementation	2,800	3,600	3,100	5,500
Spaceflight tracking and data network operations	55,600	58,700	56,200	64,500
Deep space network systems implementation	61,200	82,400	79,300	82,600
Deep space network operations	105,800	109,700	109,700	119,000
Aeronautics, balloons, and sounding rocket systems implementation	14,800	14,700	12,600	17,600
Aeronautics, balloons, and sounding rocket operations	20.500	22.600	22.100	25.400
Total	260.700	291.700	283.000	314.600

OBJECTIVES AND STATUS

Three broad categories of missions depend on the Ground Networks: (1) Earth orbital; (2) planetary and solar system exploration; and (3) sub-orbital aeronautics, balloons, and sounding rockets. The Deep Space Network (DSN) is required by the planetary and solar system exploration missions as well as by Earth orbital missions not compatible with Tracking and Data Relay Satellite System (TDRSS) Space Network. Aeronautical, balloon and sounding rocket research requires specially instrumented ranges as well as mobile systems. The Spacecraft Tracking and Data Network (STDN) stations at Merritt Island, Florida; Bermuda; and Dakar, Senegal, are required during the launch phase of Space Transportation System (STS) missions. The DSN stations and the STDN stations also provide emergency coverage of Earth orbiting spacecraft if they become unable to communicate through the TDRSS space network. Range safety functions are provided via Bermuda and Wallops. Some emergency orbital telemetry and spacecraft control is provided to scientific satellites by the STDN. The requirements of STS landings at the Dryden Flight Research Facility (DFRF) are met by the aeronautics tracking facility of the Western Aeronautical Test Range (WATR) at DFRF and the Goldstone 9 and 26 meter stations of the DSN. The Wallops Flight Facility (WFF) is used for tracking orbital scientific spacecraft, Space Transportation System, and routine aeronautics, balloons, and sounding rockets activities.

The Ground Networks funding provides for the operation and maintenance of the worldwide tracking facilities. Implementation funds are used for engineering and the procurement of hardware and software to sustain and modify network capabilities as required for new missions.

The workload in FY 1993 will include the STS, Mars Observer, Galileo, Ulysses, Magellan, the Pioneers, International Cometary Explorer (ICE), and the Voyager missions in addition to the aeronautics, balloons, and sounding rockets missions. Preparations are underway for the International Solar Terrestrial Physics (ISTP) series, Cassini, Small Explorer (SMEX), Search for Extraterrestrial Intelligence (SETI), United States/Japanese cooperative Advanced Earth Observing Satellite (ADEOS), and United States/Canadian cooperative Synthetic Aperture Radar Satellite missions (RADARSAT).

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) systems implementation	2,800	3,600	3,100	5,500

OBJECTIVES AND STATUS

The STDN systems implementation program encompasses the procurement of hardware and engineering services to sustain, modify, and replace existing ground network capabilities to ensure reliable tracking, command and data acquisition required by NASA's STS missions.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $0.5 million reflects program adjustments that were made to accommodate a portion of the general reduction specified by Congress. This will delay the replacement of the ultra high frequency (UHF) air-to-ground voice communication systems at Bermuda and Merritt Island that are needed for STS missions.

BASIS OF FY 1993 ESTIMATE

The FY 1993 request provides funds to upgrade equipment and subsystems required for STS operations at the Merritt Island, Florida, and Bermuda STDN tracking stations. It also includes funding for the replacement of obsolete, difficult-to-maintain equipment at these tracking stations. Projects starting in FY 1993 include replacement of the transmitters for STS commanding and replacement of obsolete antenna control consoles.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) operations	55,600	58,700	56,200	64,500

OBJECTIVES AND STATUS

The primary function of the STDN is to provide prelaunch, launch, and landing communications required by the Space Transportation System (STS). In addition, this network provides emergency backup for orbiting spacecraft in the event that they are unable to communicate through the TDRSS/Space Network. The network also meets similar requirements of other U.S. government agencies, private industry, and international organizations on a reimbursable basis.

The STDN consists of three ground stations, which are located at Bermuda; Merritt Island, Florida; and Dakar, Senegal. Each station is capable of tracking spacecraft, transmitting commands for spacecraft and experiment control, and receiving engineering and scientific data from the spacecraft. They also provide primary and backup voice communications for STS operations and range safety functions of Eastern Test Range operations.

The STDN logistics program includes a central supply depot, a magnetic tape purchasing and certification facility, and centralized equipment repair and shipping facility. The depot is operated as a centralized facility, and services the Communications and Data Systems program, the Deep Space Network, the Space Network, the Aeronautics, Balloons, and Sounding Rocket program, and the STDN. It is managed by the Goddard Space Flight Center (GSFC).

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $2.5 million was necessary to accommodate a portion of the general reduction specified by Congress. It results in a drawdown of logistics depot materials.

BASIS OF FY 1993 ESTIMATE

The FY 1993 request provides for the operation and maintenance of the three ground stations, centralized logistics operations, and limited tracking purchased from the Department of Defense and the University of Chile.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Deep space network (DSN) systems implementation	61,200	82,400	79,300	82,600

JECTIVES AND STATUS

The primary role of the DSN is to provide communication between interplanetary spacecraft and the Earth. The DSN receives science and engineering telemetry, and transmits command, control and navigation signals to a variety of spacecraft, at distances as great as 8 billion kilometers from Earth.

The systems and facilities required by spacecraft at the limits of the solar system are highly specialized and include large aperture antennas which can receive extremely weak radio signals. These antennas use ultra-sensitive receivers and powerful transmitters. Extremely stable time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the Network Operations Control Center located at the Jet Propulsion Laboratory (JPL) and the deep space communications complexes located in California, Spain, and Australia. An orderly, phased upgrade program has been established to increase DSN capacity and incorporate new required capabilities for current and future missions. These improvements are needed to accommodate the increasing number and sophistication of spacecraft. Specific improvements include: additional antenna subnetworks which can be arrayed together (combined electronically) to effectively improve performance; and new frequency capability for greater data rates. New systems implementation is required for the Mars Observer mission, the Search for Extraterrestrial Intelligence project (SETI), the two cooperative Orbiting Very Long Baseline Interferometry Astronomy missions (Japan's VSOP, and the Soviet Radioastron), Cassini, and two Earth observation missions -- the joint United States/Canadian Cooperative Synthetic Aperture Radar Satellite (RADARSAT) and the United States/Japanese cooperative Advanced Earth Observation Satellite (ADEOS) mission.

The major objectives of the DSN are: (1) to provide communications with scientific spacecraft at ever greater distances and to increase the capability to receive data from the far reaches of the solar system; (2) to meet the requirements of Earth orbiting spacecraft which are non-TDRSS compatible; (3) to provide the navigation capabilities for precision spacecraft targeting and probe delivery; and (4) to provide the increasing network frequency range and data rate capabilities required by new deep space missions.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $3.1 million reflects program adjustments that are being made to accommodate a portion of the general reduction specified by Congress. As a result, implementation of the Orbiting Very Long Baseline Interferometry (OVLBI) Radio Astronomy mission capability may be delayed.

BASIS OF FY 1993 ESTIMATE

The FY 1993 funding provides for sustaining activities to keep the Deep Space Network functioning in a highly reliable manner. The funding request provides for a new DSN subnet of 11-meter antennas and modification of the Greenbank Radio Observatory 14-meter antenna for use in the OVLBI cooperative missions with NASA's Japanese and Soviet partners. In addition, implementation activities continue for Cassini and begin for RADARSAT and ADEOS.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Deep space network operations	105,800	109,700	109,700	119,000

OBJECTIVES AND STATUS

The three DSN complex locations (Goldstone, California; Canberra, Australia; and Madrid, Spain) are approximately 120 degrees apart in longitude to permit continuous viewing of planetary spacecraft. Each complex has four antennas -- one 70-meter, two 34-meter, and one 26-meter. The 26-meter antennas are required by some Earth orbiting spacecraft, such as Nimbus-7 and Solar-A, and for emergency backup functions. The complexes are staffed for around-the-clock operations. A central network control center is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. Other DSN facilities include a spacecraft compatibility test area at JPL and a launch operations and compatibility facility at the Merritt Island Spaceflight Tracking and Data Network (STDN) site.

Since 1989, three interplanetary spacecraft, which require telecommunications with the DSN, have been launched -- Magellan, Galileo, and Ulysses. Magellan began mapping the planet Venus in 1990, and has mapped more than 90 percent of that planet to date. Galileo recently flew within 1,000 miles of the asteroid Gaspra, the first U.S. spacecraft to encounter an asteroid. Later this year, Galileo will receive the second of two gravity assists from Earth flybys before the spacecraft begins the initial phase of its journey to Jupiter.

Ulysses will fly past Jupiter in early February 1992, where it will receive a gravity assist to deflect it on a trajectory to the Sun's polar regions. In September, Mars Observer will be launched and will arrive at Mars in 1993. During this coming summer, the DSN will assist the European Space Agency (ESA) in acquiring data from comet Grigg-Skjellerup with the Giotto spacecraft. The DSN also provides communications for the Voyagers, the Pioneers, and International Cometary Explorer (ICE) spacecraft, as well as for several cooperative and reimbursable programs.

In response to the increasing telecommunications requirements, the capacity of the DSN will be increased through the phased implementation of additional antennas throughout the next decade. The construction of these antennas are funded within the Construction of Facilities (CoF) budget.

The DSN facilities are also used for ground-based measurements in solar system radar and radio astronomy observations. The network's ultra-sensitive antennas are being used in an attempt to learn more about pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena. The solar system radar is useful in understanding surface characteristics of planets, asteroids, comets, moons, including near-Earth asteroids, and ring systems.

BASIS OF FY 1993 ESTIMATE

The DSN operations funding provides for the maintenance and operation of network facilities and the engineering required for continuing operation of the network. The expected DSN workload in FY 1993 includes Galileo (including an Earth gravity assist maneuver), Ulysses, and Mars Observer, as well as a variety of other missions. These include Pioneers 10 and 11; Pioneer-Venus; Voyagers 1 and 2; International Cometary Explorer (ICE): Nimbus-7; Solar-A; Geotail; and STS landings. The Pioneer-Venus spacecraft is expected to be destroyed after entering the Venusian atmosphere in late FY 1992/early FY 1993. The DSN will also provide emergency and backup communications for the TDRSS Space Network. Major TDRSS users include STS, Hubble Space Telescope (HST), Compton Observatory, Cosmic Background Explorer (COBE), and Upper Atmospheric Research Satellite (UARS).

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Aeronautics, balloons and sounding rocket (AB&SR) systems implementation	14,800	14,700	12,600	17,600

OBJECTIVES AND STATUS

The Aeronautics, Balloons, and Sounding Rocket (AB&SR) systems implementation program is directed primarily at the replacement of obsolete systems and the upgrade of facilities to assure reliable service to NASA's research programs.

The facilities provide the ground capabilities required to capture the scientific and engineering data from research aircraft, balloons, sounding rockets and some Earth-orbiting spacecraft engaged in scientific research. The primary fixed facilities are located at the Wallops Flight Facility (WFF), the Moffett Field Flight Complex (MFFC), and the Dryden Flight Research Facility (DFRF).

The WFF, under the management of the Goddard Space Flight Center (GSFC), operates a range at Wallops Island, Virginia, which conducts aeronautics research as well as sounding rocket and small meteorological balloon launches. The WFF also manages the operation of off-site ranges located at the White Sands Missile Range, New Mexico; Poker Flat Research Range, Alaska; and the National Scientific Balloon Facility, at Palestine, Texas. In cooperation with the National Science Foundation (NSF), a transportable facility will be provided at McMurdo Sound, Antarctica to meet the requirements of the joint US/Canadian Synthetic Aperture Radar Satellite mission (RADARSAT). Mobile campaigns for balloon and sounding rocket launches are conducted at various sites, as required, throughout the world. The funding in this budget is used to provide tracking and data acquisition for these activities.

The ranges at Moffett Field, Crows Landing and the DFRF are under the management of Ames Research Center (ARC) and are configured for aeronautics research. The DFRF has the additional responsibility of providing tracking for STS landings.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $2.1 million reflects program adjustments being made to accommodate a portion of the general reduction specified by Congress. This decrease will be accommodated by deferring the replacement of balloon facility telemetry equipment and deferring the replacement of radar and communications systems at DFRF and WFF.

BASIS OF FY 1993 ESTIMATE

The aeronautical research efforts and scientific experiments using sounding rockets and balloons require fixed and mobile instrumentation systems. These include radar, telemetry, optical, communications, command, data handling and processing systems. To maintain these facilities, replacement parts must be acquired, test and calibration equipment routinely replaced, and equipment refurbished or modified to assure reliable performance. Funds are also included for acquisition of new mobile tracking systems for NASA's Small Explorer program, and RADARSAT.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons, and sounding rocket (AB&SR) operations	20,500	22,600	22,100	25,400

OBJECTIVES AND STATUS

The operations element of the AB&SR program includes the operations and maintenance of ground-based tracking instrumentation systems, both fixed and mobile, under the management of the ARC and the Goddard Space Flight

Center (GSFC). These facilities are employed for NASA aeronautics, sub-orbital, and a limited number of Earth-orbiting research programs. Funding provides for services required to operate and maintain the tracking radar, telemetry, data acquisition, data processing, data display, communications and special purpose optical equipment essential for these research programs.

The Western Aeronautical Test Range (WATR), composed of Dryden Flight Research Facility (DFRF) and the Moffett Field Flight Complex (MFFC), maintains an aggressive schedule of aeronautics research operations. During FY 1991, 1,116 missions were conducted at DFRF and MFFC. The trend continues upward in FY 1992 with approximately 1,492 aeronautical missions planned. Programs tracked from these ranges included high performance aircraft, advanced technology research aircraft, and complex control systems and powered lift technologies. STS tracking and telemetry landing operations are coordinated through DFRF.

The Wallops Flight Facility (WFF) provides tracking, telemetry, and command functions for NASA's aeronautics, sounding rocket, balloon and some Earth orbiting satellite programs. During FY 1991, approximately 150 aeronautics missions were conducted. These were related to such programs as automatic landing operations using Global Positioning Satellite inputs, aircraft performance using vortex flap technology, radar surveillance technology service, runway friction testing, and cooperative programs with DOD for low cost launch vehicle operations. Approximately the same number of aeronautics missions will be conducted in FY 1993.

In FY 1991, WFF highly specialized mobile tracking systems were used by 25 major sounding rocket missions in worldwide campaigns. Approximately 38 sounding rocket missions are planned in FY 1992. In addition, WFF routinely launches smaller meteorological and special purpose rockets associated with specialized research programs. The WFF is also the center for a scientific balloon operations program. In FY 1991, WFF mobile tracking and telemetry systems launched 28 large balloons of the 3 to 30 million cubic foot class for major scientific payloads, and in FY 1992, 45 large balloon launches will occur.

In FY 1992, the Wallops Orbital Tracking Station will provide 24 hour space tracking operations for missions such as Cosmic Background Explorer, International Ultraviolet Explorer, Interplanetary Monitoring Platform-8, Nimbus-7, Meteosat and Landsat, NOAA-10, Total Ozone Mapper (TOMS)/Meteor-3, and Roentgen Satellite (ROSAT).

CHANGES FROM PY 1992 BUDGET ESTIMATE

The decrease of $0.5 million reflects program adjustments that are being made to accommodate a portion of the general reduction specified by Congress. This will require rephasing the depot upgrade of a DFRF tracking radar system.

BASIS OF FY 1993 ESTIMATE

The funding for AB&SR program operations includes support services contractor operations and maintenance personnel, and technical services for the ground-based fixed and mobile instrumentation systems for the ongoing sounding rocket, balloon, Earth orbiting satellite and aeronautical research programs; commensurate with an increased mission workload, including the funds necessary to prepare for Antarctic operations to meet RADARSAT requirements.

BASIS OF FY 1993 FUNDING REQUIREMENT

COMMUNICATIONS AND DATA SYSTEMS

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Communications systems implementation.	11,600	10,300	10,300	8,700
Communications operations	118,189	129,600	123,400	131,200
Mission facilities	8,800	22,000	14,000	17,100
Mission operations	41,400	44,900	48,400	52,500
Data processing systems implementation	22,400	39,800	23,600	30,000
Data processing operation	55,600	67,600	61,700	68,700
Total	257,989	314,200	281,400	308,200

OBJECTIVES AND STATUS

The Communications and Data Systems program provides for the development and operation of facilities and systems that are required for data transmission, mission control and data processing for space flight missions. The requirements for these functions are increasing sharply as new flight missions are overlaid on the continuing operations of older spacecraft. FY 1991 began with the continued operation of 8 spacecraft: Cosmic Background Explorer (COBE), Earth Radiation Budget Satellite (ERBS), Dynamics Explorer (DE), Hubble Space Telescope (HST), International Cometary Explorer (ICE), Interplanetary Monitoring Platform-8 (IMP), International Ultraviolet Explorer (IUE), and NIMBUS. The Dynamics Explorer mission, an older spacecraft of limited complexity, was terminated in 1991. During the past year, two major observatories were launched: the Compton Observatory and the Upper Atmosphere Research Satellite (UARS). Each observatory has corresponding spacecraft control and data processing facilities that were completed and placed into operation. The addition of the Compton and UARS observatories to NASA's operational fleet has nearly doubled the quantity of scientific data processed by the Office of Space Communications systems relative to last year.

Communications circuits and services provide for the transmission of data between and among the remote tracking stations, the Tracking and Data Relay Satellite System (TDRSS) Ground Terminal, launch areas, the mission control centers, and data processing facilities. Real-time information is crucial to determine the condition of the spacecraft and payloads, responding to failures or dangerous situations, and for the generation of spacecraft and payload control commands. Data received from the various spacecraft must be transformed into a form usable for spacecraft monitoring in the control centers, and for analysis by the scientific investigation team.

In addition to operating spacecraft, preparations are underway for several new missions to be launched in the near future, including Wind, Polar, Geotail, Solar and Heliospheric Observatory (SOHO), Cluster, Sampex, FAST, SWAS, and the Tropical Rainfall Measurement Mission (TRMM). The Space Shuttle will carry several Spacelab and attached payloads into orbit this year, and data processing preparations are nearing completion for these missions.

To meet the increasing requirements in terms of both quantity of spacecraft being operated and the much larger volumes of data being produced by the newer spacecraft, it is necessary to modernize our facilities to expand system capacity and replace aging equipment that is becoming increasingly costly to maintain. The application of advanced technologies such as high-speed Very Large Scale Integration (VLSI) and distributed systems using the new powerful microcomputers is being tested and incorporated into our new facilities.

In the communications area, planning is underway to transfer many of the domestic (intra-U.S.) transmission services of NASA's global communications network for operational missions (NASCOM) onto the FTS-2000 network. Because of the critical nature of NASCOM, special arrangements are being made with the General Services Administration (GSA) to provide the reliability and diversity requirements that the current NASCOM provides. When these arrangements are completed, circuit transfers will begin and will continue through FY 1993. The transfer of services to FTS-2000 include those services that are less than 1.5 million bits per second (M b/s). The high speed data services (greater than 1.5 M b/s) and overseas services will not be transferred to FTS-2000.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation.	11,600	10,300	10,300	8,700

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The objective of the Communications Systems Implementation program is to provide the necessary capability in NASCOM to meet new flight program requirements, to increase the efficiency of the network, and to maintain a high level of reliability and security for the transmission of data and commands between U.S. assets in space and their respective control centers.

Major systems implementation projects expected to be completed in FY 1993 that were initiated in prior years include: (1) the upgrade of the data handling capability of the Deep Space Network (DSN) from 1.5 M b/s to approximately 6.0 M b/s; (2) the implementation of a fiber optic system connecting the two TDRSS ground terminals at the White Sands complex; and (3) the implementation of a new backbone multiplexer/demultiplexer (MDM) system between the White Sands complex, the Goddard Space Flight Center (GSFC), and the Johnson Space Center (JSC).

BASIS OF FY 1993 ESTIMATE

The FY 1993 funding will provide the necessary equipment acquisitions and sustaining engineering modifications required for completion of projects begun in earlier fiscal years. Of particular note is the completion of the MDM replacement/upgrade at GSFC and JSC, the acquisition of a new digital matrix switch at the GSFC for greater circuit handling capability and the continuing upgrade of the DSN to meet the data requirements of the Wind, Polar, and SOHO missions which are part of the International Solar Terrestrial Program (ISTP).

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Communications operation	118,189	129,600	123,400	131,200

OBJECTIVES AND STATUS

The NASCOM network knterconnects the tracking and data acquisition facilities for all flight projects via leased voice, data, video, and wideband circuits. The overseas elements of NASCOM employ sub-switching centers at the Jet Propulsion Laboratory (JPL) and the Madrid complex to improve diversity, connectivity to multiple overseas destinations, and to achieve optimum utilization of circuit bandwidth. Direct services from Madrid and Australia to the JPL are being established in FY 1992 to economically provide the increased bandwidth required by new spacecraft under development. When operational, the existing lower speed services will be discontinued.

The NASCOM program includes the Agency's television service, NASA SELECT, which allows the American public to witness all manned spaceflight missions and learn of the important discoveries of the scientific missions such as Magellan. NASA SELECT will continue to be used for educational outreach with a potential audience of most universities and high schools, and will extend its coverage to Hawaii and parts of Alaska in FY 1992.

NASA's Program Support Communications Network (PSCN) interconnects the NASA Centers, Headquarters, major contractors, and university locations for the transfer of programmatic and scientific information. The PSCN services include computer networking, electronic mail and voice and video teleconferencing. As of September 30, 1991, FTS-2000 is now providing the transmission system that services the PSCN. The Marshall Space Flight Center (MSFC) operates the PSCN and serves as its control center.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $6.2 million reflects program adjustments to the PSCN that include delaying implementation of new requirements and deferring planned improvements of existing services. The adjustments also reflect fewer Shuttle missions and the sharing of existing resources. Augmentations planned, such as the upgrade of the Time Division Multiple Access (TDMA) system in NASCOM, have been deferred until FY 1994 when new service requirements are anticipated in preparation for the Space Station Freedom (SSF).

BASIS OF FY 1993 ESTIMATE

The requested FY 1993 funding for the communications operations program provides for the increased system capacity needed for the upcoming ISTP missions, the preparations necessary to begin testing the operations of the newly completed TDRSS ground terminal at the White Sands complex, and full-year funding for the wideband links to Madrid and Australia. The PSCN provides for the circuits, facilities, and systems integration for programmatic and institutional communications operations. PSCN services include computer networking, voice and video conferencing, facsimile, and electronic mail. In FY 1993, funds are required for continued operation, maintenance, and systems integration of the PSCN hardware and wideband satellite and terrestrial circuits at all NASA locations and certain contractor sites. Network services are required by all NASA programs and projects.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Mission facilities	8,800	22,000	14,000	17,100

OBJECTIVES AND STATUS

The Mission Facilities program provides the systems and capabilities needed for the command and control of NASA's unmanned scientific satellites. Command and control of the spacecraft and on-board experiments are carried out by the respective Payload Operations Control Centers (POCCs) and other facilities used for many spacecraft.

The POCCs are responsible for the receipt, processing, and display of spacecraft engineering data and the generation of commands. Four POCCs currently monitor and control 9 spacecraft. In FY 1991, mission control capabilities were implemented for the Compton Observatory and UARS in the existing Multi-satellite Operations Control Center. Future spacecraft POCCs, starting with the Small Explorers (SMEX) POCC, are being implemented with distributed workstations to take advantage of the increased processing capability and lower cost provided by the new powerful workstations. Other related mission systems include a JSC/GSFC Shuttle POCC Interface Facility (SPIF) and a Mission Planning/Command Management System to schedule spacecraft communications periods and generate command sequences for transmission by the POCCs to the spacecraft.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The decrease of $8.0 million reflects a rephasing of the Advanced X-ray Astrophysics Facility (AXAF) program mainly due to a launch delay and planned efficiencies in the development of the SMEX POCC to be gained through the reuse of the SMEX 1 POCC systems for SMEX 2.

BASIS OF FY 1993 ESTIMATE

The FY 1993 budget request includes funds for continued implementation of mission control capabilities at GSFC for the Small Explorer missions and the Hubble Space Telescope (HST) control center modifications needed to prepare for the upcoming FY 1994 repair mission. The repair mission will restore the optical performance of the combined telescope-instrument system, install a new Wide Field and Planetary Camera (WFPC) and solar arrays, and replace equipment such as the gyroscopes that failed on-orbit. New equipment must be added to the HST POCC for developing software needed by the new HST flight equipment and to carry out the lengthy system testing required prior to executing the repair mission. The repair mission will be carried out by astronauts performing extravehicular activities to accomplish the difficult job of equipment removal and replacement on orbit. Funds are also needed to procure equipment to implement control center facilities for the upcoming TRMM, SOHO, X-Ray Timing Explorer (XTE), and Total Ozone Mapping Spectrometer (TOMS) missions.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Mission operations	41,400	44,900	48,400	52,500

OBJECTIVES AND STATUS

The Mission Operations program provides for the operation of the mission control centers and the related software and services necessary for the monitoring and control of in-orbit spacecraft and prelaunch preparations for new spacecraft.

Control facilities for spacecraft/payload operations have the capability for receiving, processing, and displaying spacecraft engineering and telemetry data and for generating commands. Commands are generated in response to emergencies or preplanned in sequences and transmitted to the spacecraft to carry out the mission objectives. Software is developed for each new spacecraft, made up of approximately 50% reused standard software and 50% new mission unique software. Each facility i operated 24 hours per day, 7 days per week for mission services. For Shuttle missions with attached payloads operated by GSFC, a specialized system processes and displays Shuttle-unique data that is needed for payload control.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The increase of $3.5 million is needed to start the POCC software development needed to meet the July 1995 SOHO launch date, provide adequate software maintenance for the software used to control the on-orbit spacecraft, and to provide software for new institutional systems needed to accommodate the increasing number and complexity of spacecraft controlled by the POCCs.

BASIS OF FY 1993 ESTIMATE

The FY 1993 budget request includes funds to operate the control centers and facilities for control of the 12 missions planned to be operated in FY 1993, and to develop the control center capabilities needed for spacecraft under construction that will be launched beyond 1993. The funds will also be used for development of improvements to the planning and scheduling system for the HST, systems to offload recording and analyses functions from the now overloaded controlling computers, and provide a system to schedule the use of the TDRSS when the new second TDRSS ground terminal is in place. These enhancements are required to permit the control centers to operate with the evolving NASA ground systems, to control the increased number of spacecraft, and to accommodate the higher data rates and complexity of the new spacecraft. In FY 1993, mission control software systems will be under way for the TOMS, TRMM, XTE, and spacecraft which are part of ISTP.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
		(Thousands of Dollars)		
Data processing systems implementation	22,400	39,800	23,600	30,000

OBJECTIVES AND STATUS

The Data Processing Systems program provides for the procurement of equipment and development of data processing and computational systems at GSFC that are required by a broad range of Earth orbiting scientific missions. These systems determine spacecraft attitude and orbits, and generate attitude and orbit maneuvers for operating spacecraft. These systems also process the large volume of data produced by the operational spacecraft as a prerequisite to analysis of the data by the individual mission research projects.

Major computational capabilities include the multi-mission Flight Dynamics Facility (FDF), which performs the real-time and non-real-time attitude, orbit, flight maneuver control and ground networks functions. The current FDF architecture is a large and aged central computer that is currently approaching saturation of capacity. Near-term efforts are aimed at managing the computational oversubscription until the computer can be replaced with one of higher capacity. For the long-term, studies are under way to plan the migration of the facility toward a future distributed computing architecture with the objectives of increasing the capacity and minimizing the life cycle cost. Other activities within this program include an engineering capability used to develop and test advanced data system components. Through these facilities, advanced techniques in the areas of remote payload operation and control, expert systems, high-speed data processing, high-level languages, and VLSI will be applied to operational systems to replace costly conventional architectures and reduce operational staffing needs.

In addition, there are four major systems for processing payload data: (1) the Generic Time Division Multiplexer (GTDM) Facility, which processes data from all TDM satellites; (2) the Packet Processor (PACOR), which processes data from satellites that employ the new packet technology and protocols; (3) the Hubble Space Telescope Data Capture Facility (HSTDCF), which captures, processes, and forwards the packetized telemetry from the Hubble Space Telescope to the Science Institute Facility; and (4) the Spacelab Data Processing Facility (SLDPF), which performs the data processing required by Spacelab missions. The final success of the many missions depends on these data systems carrying out their required functions.

The large number of missions using modern packet data systems require corresponding packet data processing services. These missions include the SMEX series, SOHO, Cluster, and others. The existing PACOR capacity must be expanded to provide the required increased data processing capability in a cost-effective way, taking advantage of advances in distributed computing and VLSI digital processing. A laboratory, known as the Advanced On-board System (AOS) testbed, is being developed to evaluate advanced spacecraft data system components and the corresponding ground data handling and processing concepts to determine cost effective ways to accomplish the high performance requirements of the future.

CHANGES FROM FY 1992 BUDGET ESTIMATE

The FY 1992 budget estimate included funding for the Customer Data and Operations System (CDOS)--a system necessary to process the very high data volumes that will be created by the SSF and the Earth Observing Systems (EOS), plus funding to extend NASCOM capacity to carry this traffic. Because the data processing and communication requirements of the SSF program have been simplified as a result of last year's restructuring activity, their need for a CDOS type system has been reduced. Therefore, in order to provide greater management efficiency, CDOS is being combined with the EOSDIS program, and will be managed by the Office of Space Science and Applications (OSSA); the SSF program will provide the necessary data processing capability within their communications system. The decrease of $16.2 million reflects this reassignment of the CDOS and associated communications capability from the data processing systems program to the Earth Observing System (EOS) and SSF.

BASIS OF FY 1993 ESTIMATE

The FY 1993 budget request will provide continued funding for improvements in the existing computation capabilities at GSFC that provide services to NASA spacecraft. The budget request includes funds to begin developing additional packet data processing capacity needed first by SOHO and also by later missions under development. In addition, the AOS testbed activity is continued. Funds are also requested for upgrading the data processing capabilities at GSFC to facilitate the exchange of data within the data processing complex and to other mission service facilities.

The budget request includes funding for maintaining the reliability and availability of the FDF consistent with commitments to ongoing missions, new mission initiatives, and internal services to the space and ground networks. Acquisition of a replacement central computer, Direct Access Storage Devices, and some elements of the future distributed architecture is included in the request. The decision to acquire the replacement central computer is based on the need to continue using over 4 million lines of operating computer software code that performs the essential functions of the FDF. Conversion of these programs to the distributed architecture will take several years to accomplish. In the Data Systems Technology program, the budget request includes funding to maintain the VLSI capability developed over several years and continue to apply state of the art technologies to prototype system solutions. Development of the prototype systems will yield information on the effectiveness of proposed designs before committing to production, thereby reducing the cost and development risks to future system implementation.

	1991 Actual	1992 Budget Estimate	1992 Current Estimate	1993 Budget Estimate
	(Thousands of Dollars)			
Data processing operations	55,600	67,600	61,700	68,700

OBJECTIVES AND STATUS

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form prior to analysis by the scientific investigation teams. This transformation is performed as part of the data processing function and applies to a wide variety of missions, ranging from the small explorer satellites to more complex imaging satellites.

Telemetry data is the primary product of spacecraft, and the mission objectives are achieved through analysis of this data by the investigators. Data are processed to separate the information obtained from various scientific experiments aboard the spacecraft, to consolidate information for each experimenter, to determine spacecraft attitude, and to correlate these measurements with time and spacecraft position data. Four facilities, the GTDM, the PACOR, the SLDPF, and the HSTDCF facilities process different types of raw mission data.

The GTDM processes satellite data that is received in a time division multiplexed digits form from groun telemetry facilities via NASCOM. It is capable of electronically storing large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. The PACOR facility processes packet telemetry satellite data. The SLDPF processes Spacelab and Shuttle attached payload telemetry data and the HSTDCF provides the processing for Hubble Space Telescope data.

Facility management, maintenance, operations, application software development, and software maintenance are performed at the GTDM, PACOR, SLDPF, HSTDCF, and in the Flight Dynamics and Data Systems Technology facilities. The Flight Dynamics and Data Systems Technology facilities include the FDF, System Technology Laboratory (STL), and data systems testbeds. The FDF provides standard attitude products and services for the NASA low Earth orbital spacecraft in all phases of the mission. Premission analysis is performed to define the flight plans and to specify the Flight Dynamics software that must be developed to monitor and verify the spacecraft attitude control system. The software is developed and operated throughout the life of the missions to ensure the health and safety of the spacecraft.

ES FROM FY 1992 BUDGET ESTIMATE

The decrease of $5.9 million reflects reductions made in data systems, computer operations and maintenance, deferral of the replacement computer system used for spacecraft simulation and software research and development. Reductions were also made in the Spacelab Data Processing Facility consistent with fewer Shuttle missions.

BASIS OF FY 1993 ESTIMATE

The FY 1993 budget request provides for operation of the computational and data processing facilities: SLDPF, GTDM, PACOR, HSTDCF, FDF, STL, and the AOS testbed. Included in the facilities operation are computer operations and maintenance, rentals and leases of proprietary products, small logistics, management and control of the facility resources, and facility user assistance.

The SLDPF funding provides hardware and software services to Spacelab and Attached Shuttle Payloads. Pre-mission, mission, and post-mission activities are funded in FY 1993 for the launches of the Spacelab D2, Spacelab Life Science-2, Atlas-1, Attached Shuttle Payloads, and Hitchhikers. In addition, preparation for missions to be launched in FY 1994, such as United States Microgravity Payload (USMP-2), International Microgravity Laboratory (IML-2), Astro-2, and Atlas-3, are also funded.

The budget request includes ongoing spacecraft services for HST, ICE, ERBS, IMP, COBE, IUE, SAMPEX, Compton Observatory, UARS, EWE, and STS Spacelab and other attached payload missions to develop the software enhancements and maintenance necessary to perform spacecraft attitude control, maneuver computations, and data processing.

Premission analysis and planning to produce requirements, specifications, application software, prototyping, and system testing are also funded for the upcoming missions of Wind, Polar, SOHO, XTE, TOMS, Fast Auroral Snapshot Explorer (FAST), Submillimeter Wave Astronomy Satellite (SWAS), TRMM, and Advanced Composition Explorer (ACE).